

Beam-beam Effects at SuperKEKB

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SuperKEKB optics meeting

Oct. 08, 2013

Outline

➤ Luminosity calculation

- **BBWS**: Simple linear one-turn map, weak-strong model
- **SAD**: nonlinear one-turn map based on design lattice, weak-strong beam-beam and space-charge elements

➤ Frequency map analysis (FMA)

- **SAD**: lattice with beam-beam
- **FMA**: standard method translated to SAD script

➤ Beam tail

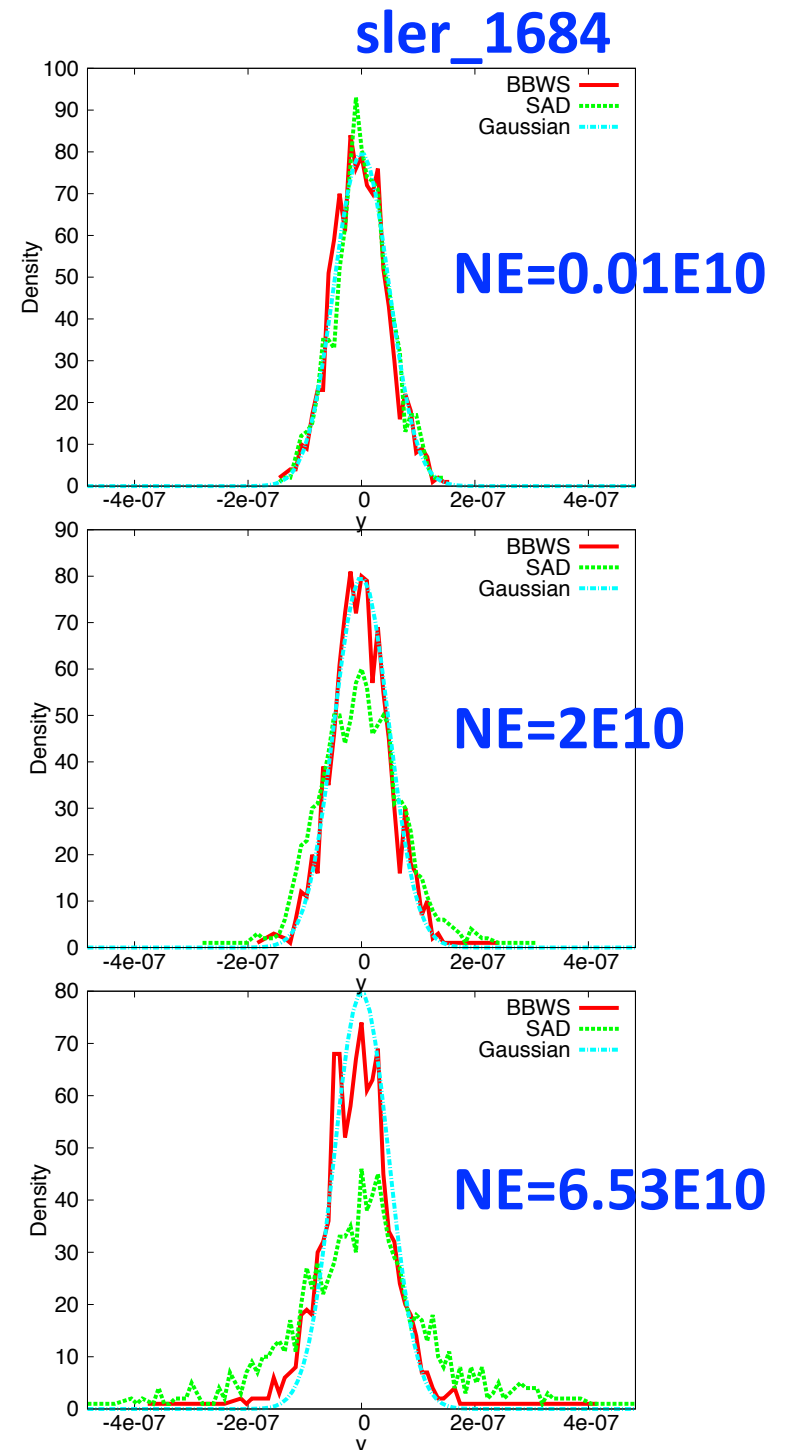
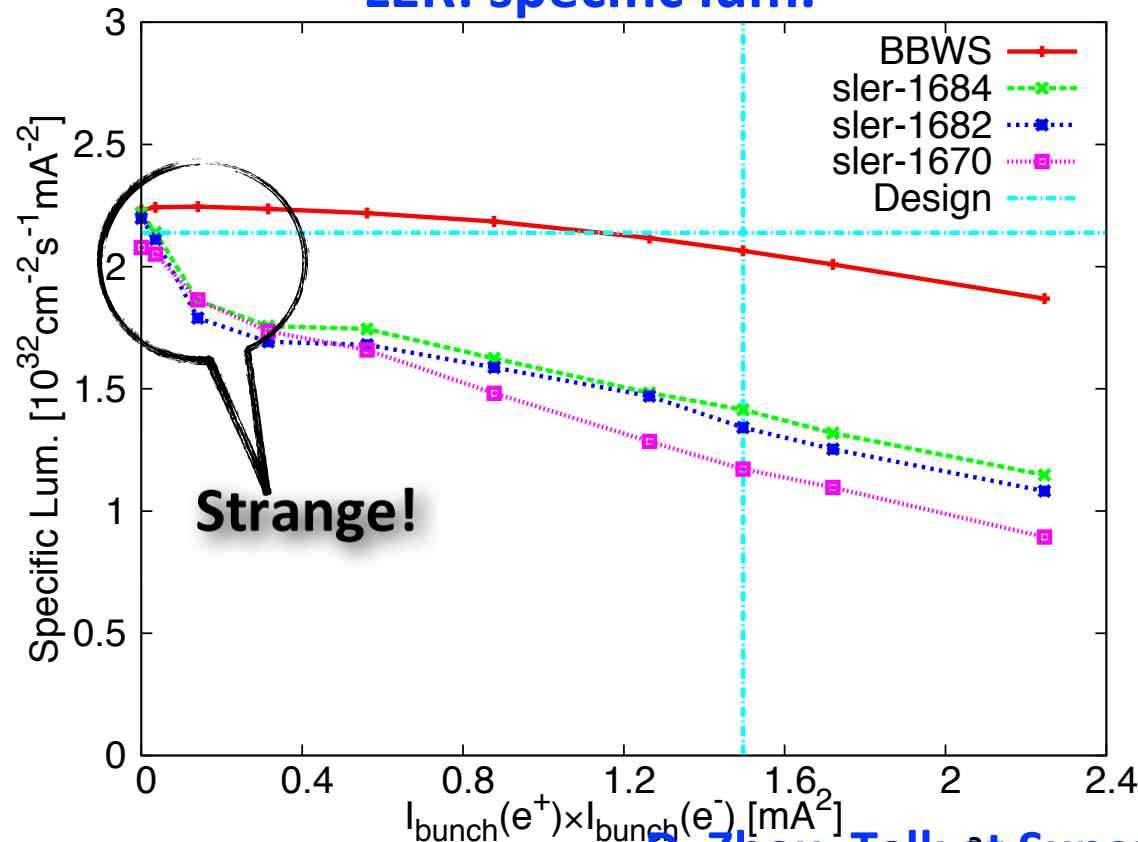
- **BBWS**: Beam-beam w/ and w/o crab waist
- **SAD**: Lattice nonlinearities and Beam-beam w/ and w/o crab waist

➤ Summary

1. Lum.: **LER**: BB + LN

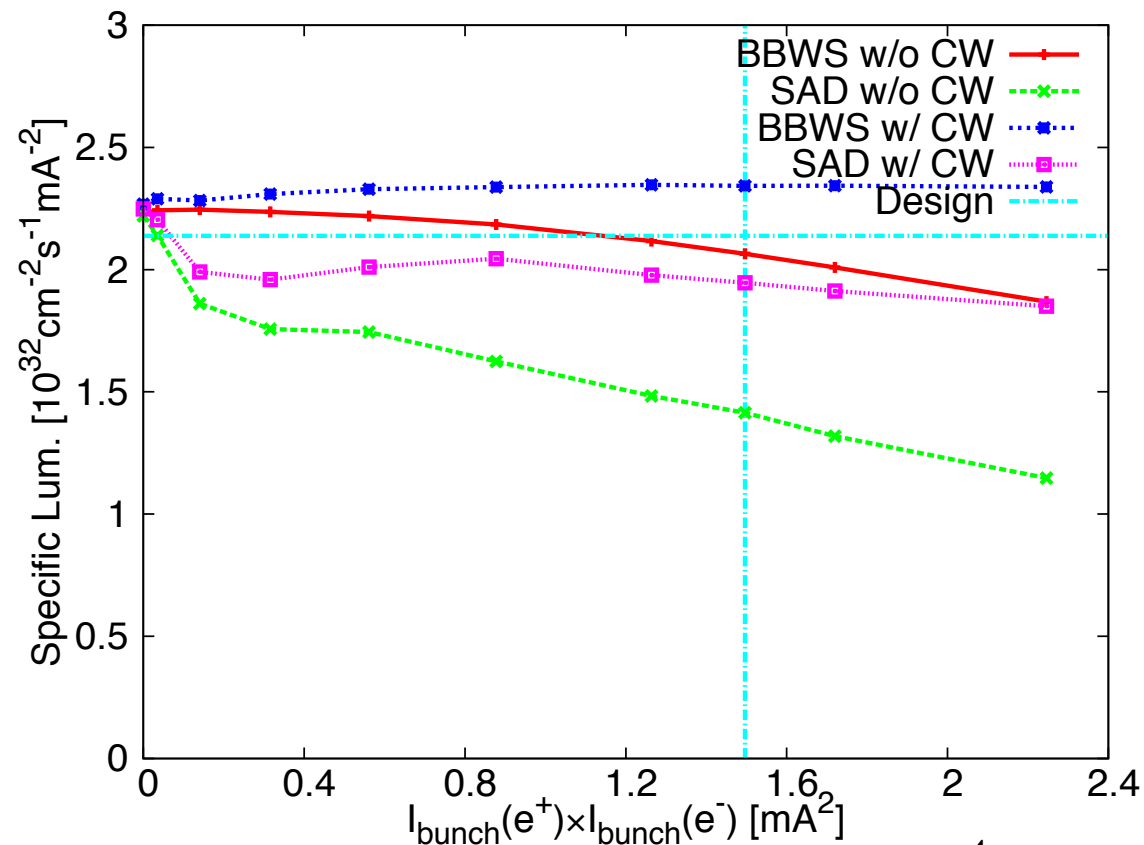
- BB: weak-strong
- Direct vert. emit. growth
- **Current dependent**
- **Lattice dependent**

LER: specific lum.



1. Lum.: **LER**: BB + Crab waist

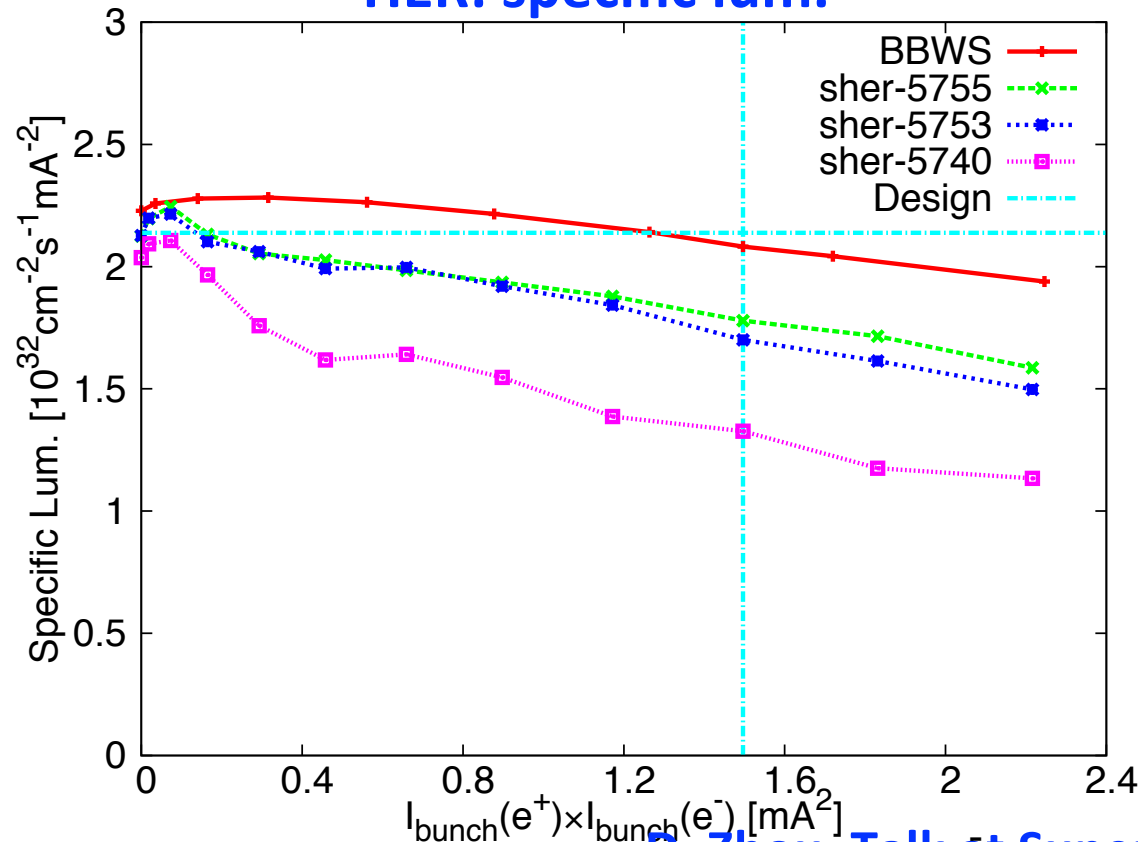
► Crab waist: simple map at IP



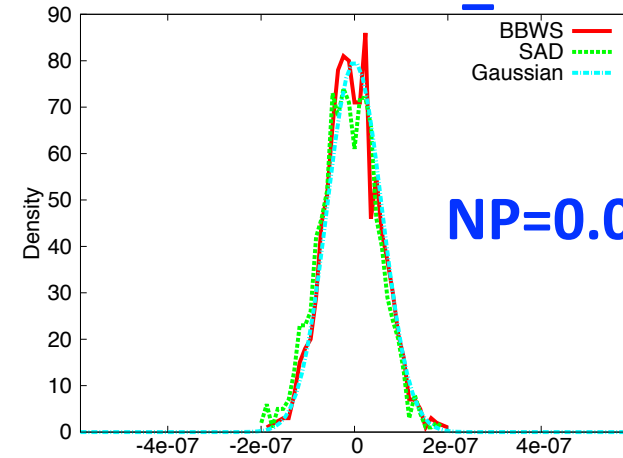
1. Lum.: **HER: BB + LN**

- BB: weak-strong
- Direct vert. emit. growth
- **Current dependent**
- **Lattice dependent**

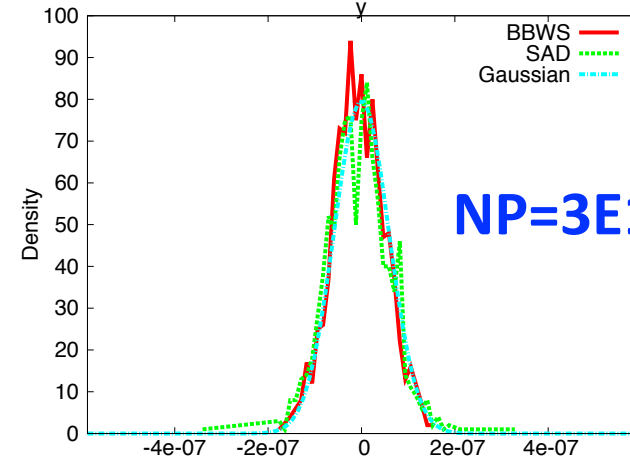
HER: specific lum.



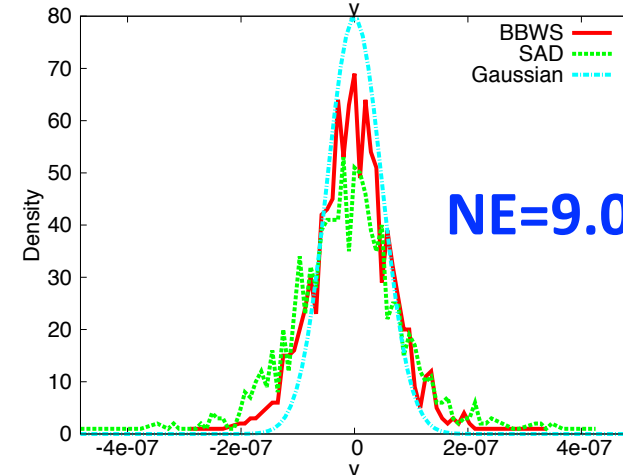
sher_5755



NP=0.01E10



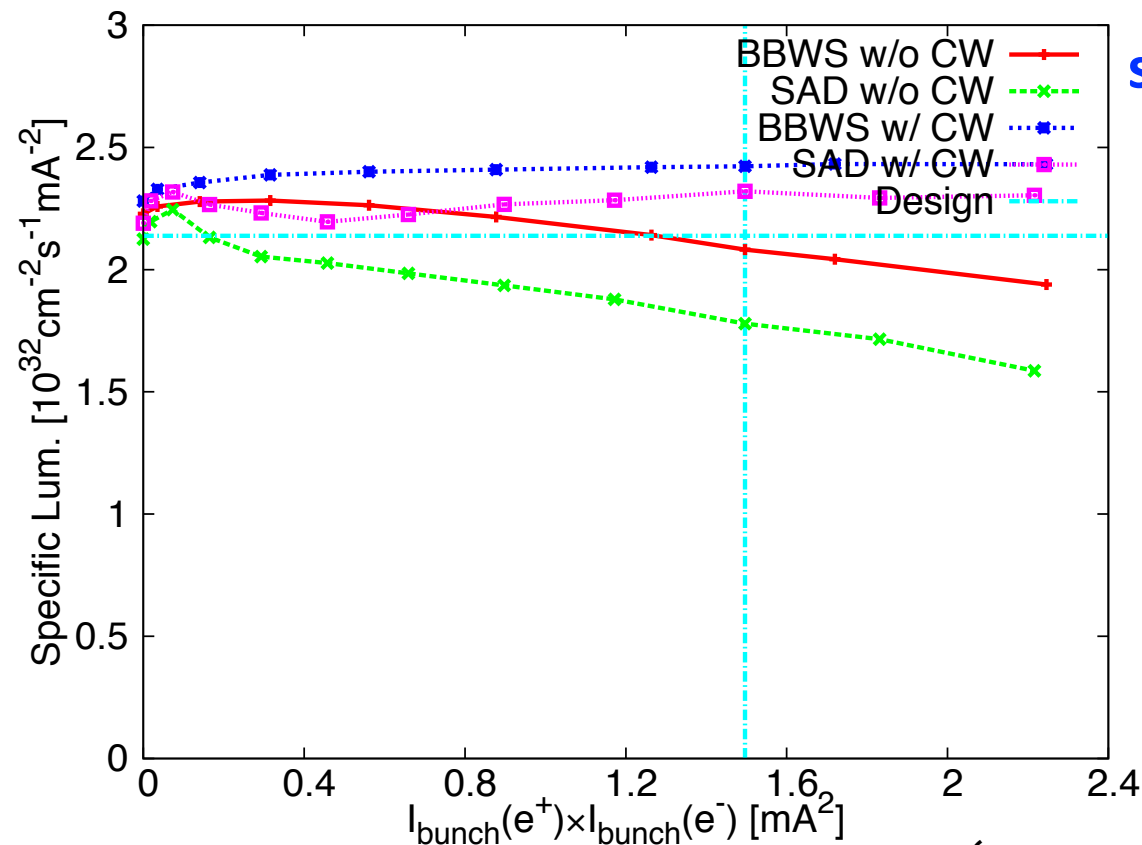
NP=3E10



NE=9.04E10

1. Lum.: **HER**: BB + Crab waist

► Crab waist: simple map at IP



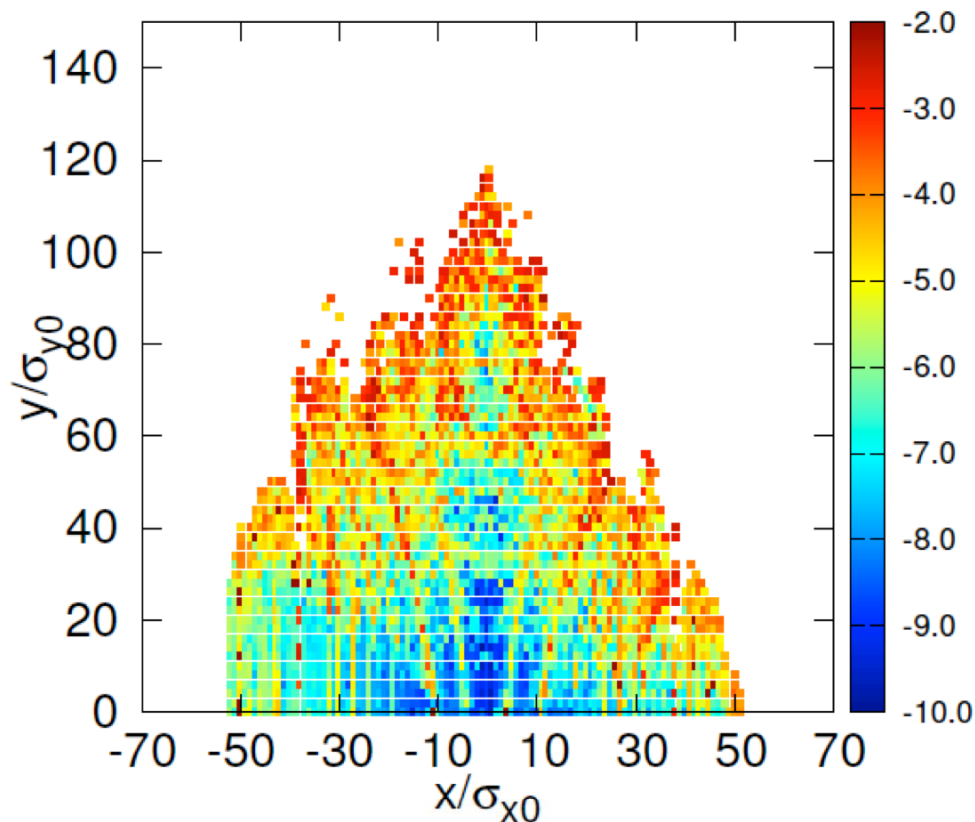
sher_5755

2. FMA: LER: x-y

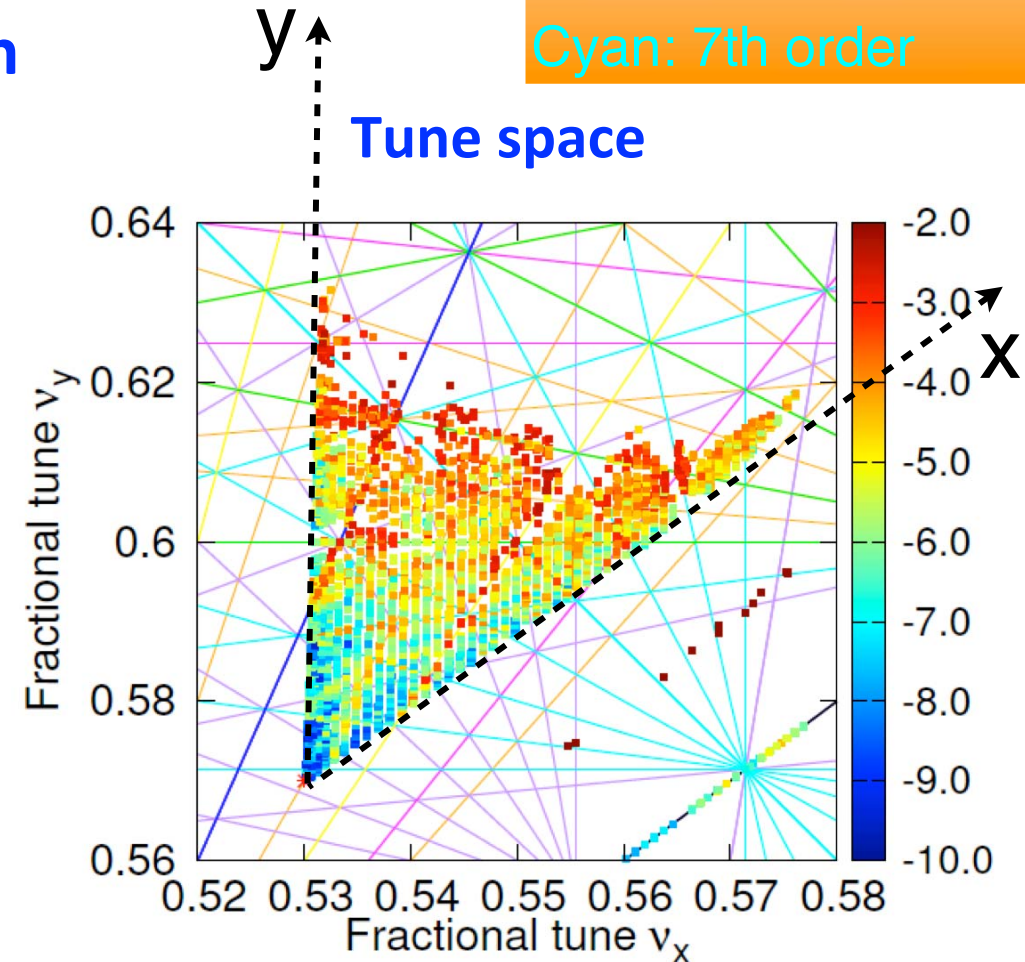
➤ DA w/o beam-beam

- On-momentum
- Strong coupling in synchrotron and betatron motions => RF on

Real space



Tune space



Resonance lines:

Blue: 4th order

Green: 5th order

Yellow: 6th order

Cyan: 7th order

2. FMA: LER: x-y

➤ DA w/ beam-beam

• On-momentum

Resonance lines:

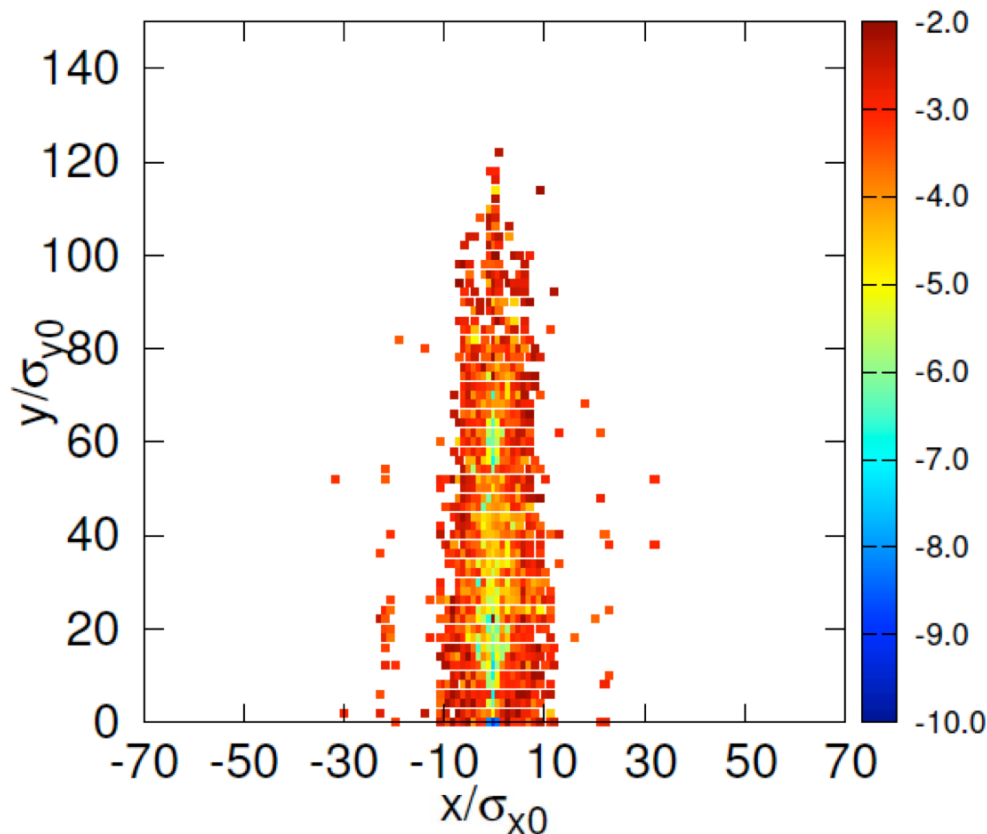
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Green: 5th order

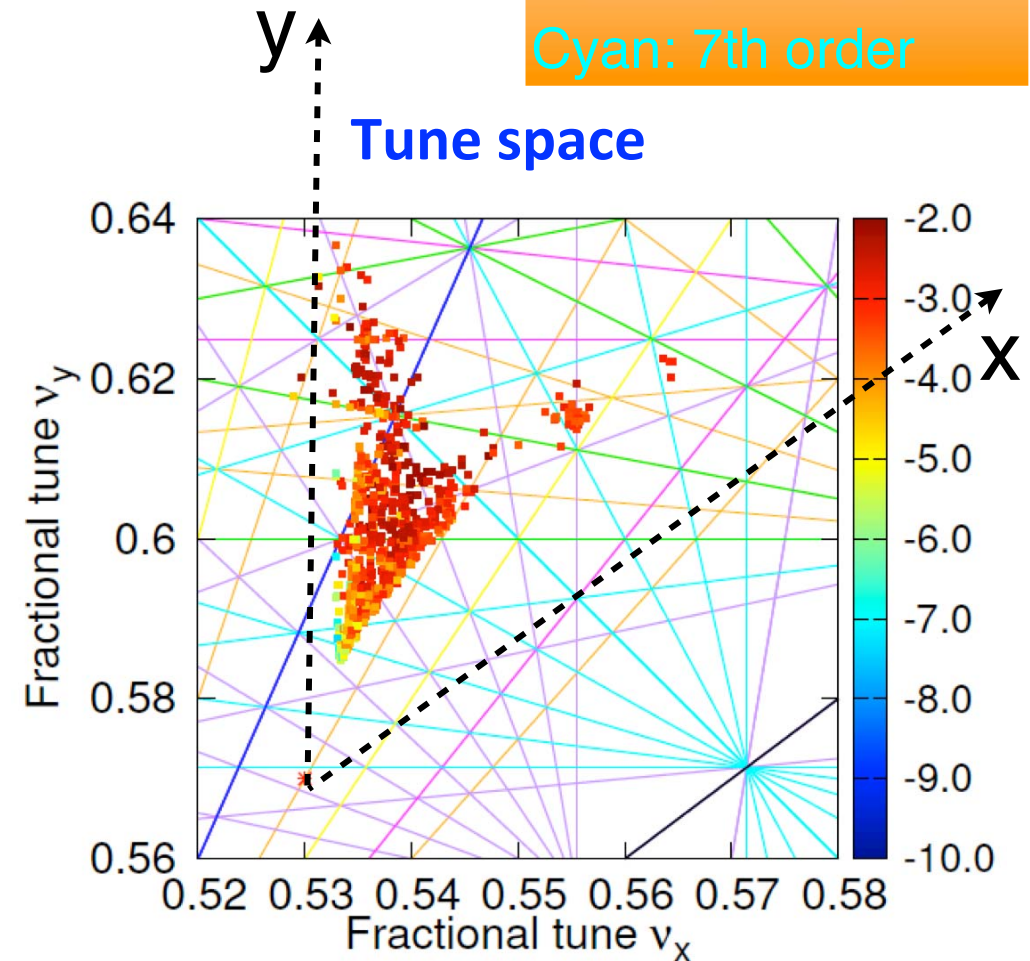
Yellow: 6th order

Cyan: 7th order

Real space



Tune space



2. FMA: LER: x-y

► Beam core: $10\sigma_x \times 10\sigma_y$

• On-momentum

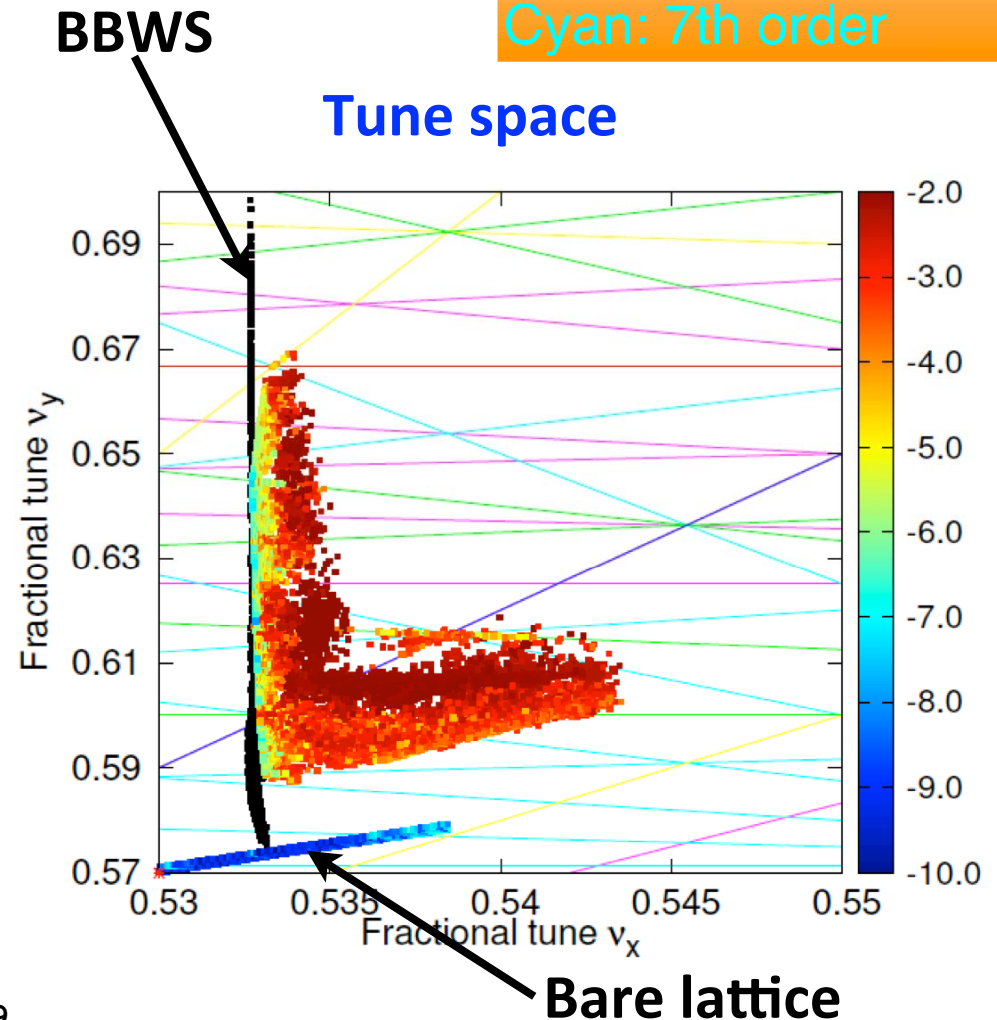
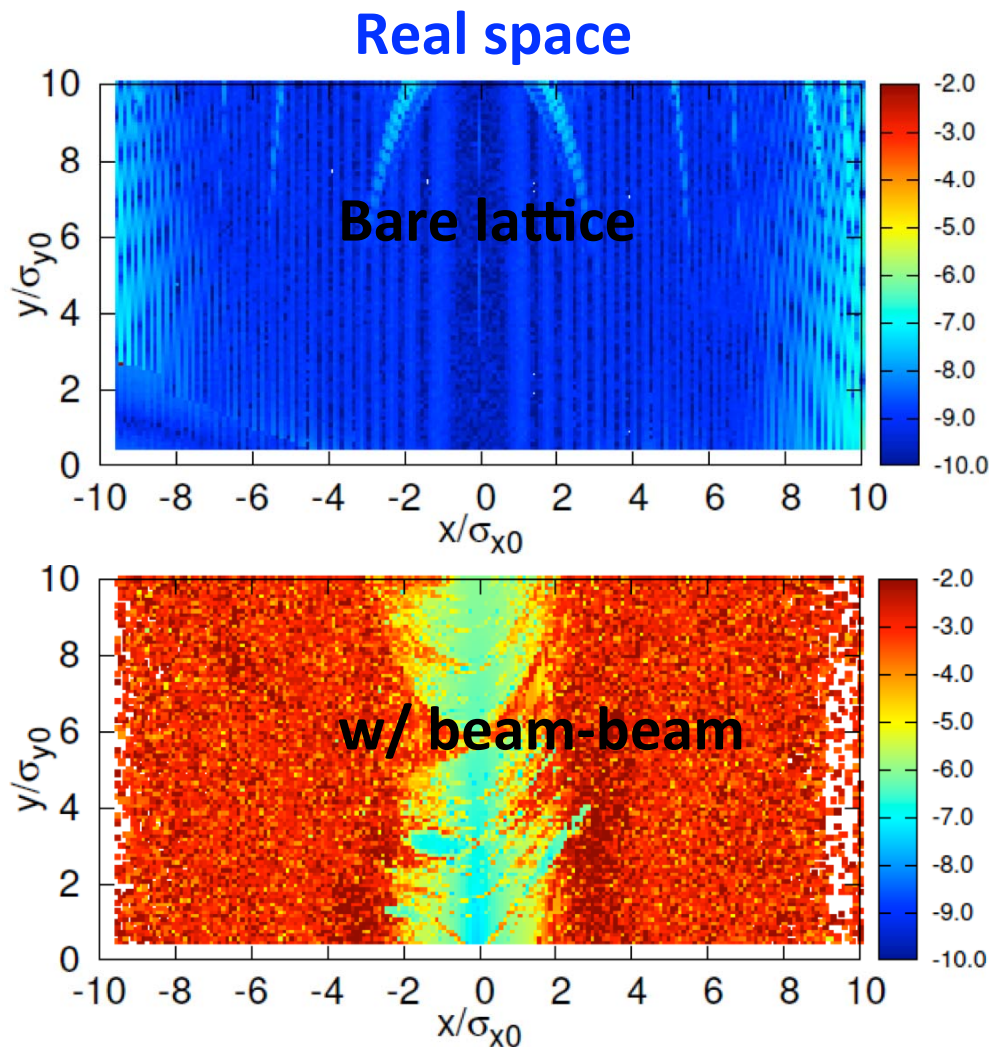
Resonance lines:

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Cyan: 7th order



2. FMA: LER: x-y

➤ DA w/ beam-beam and Crab waist

• On-momentum

Resonance lines:

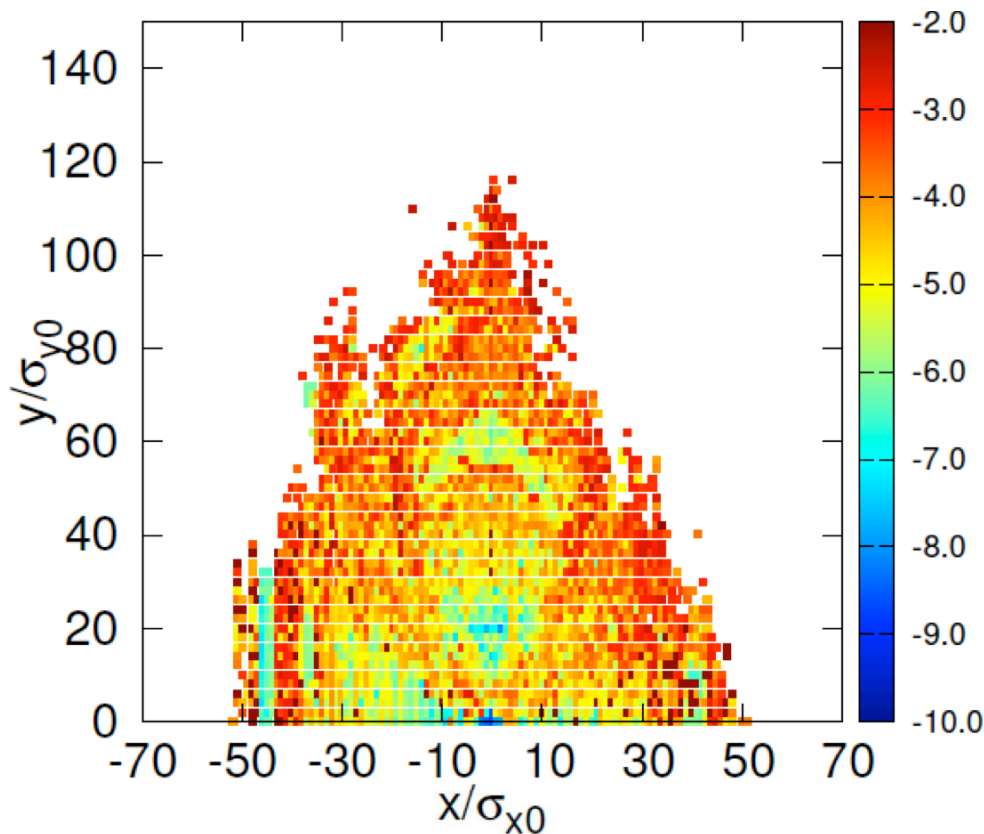
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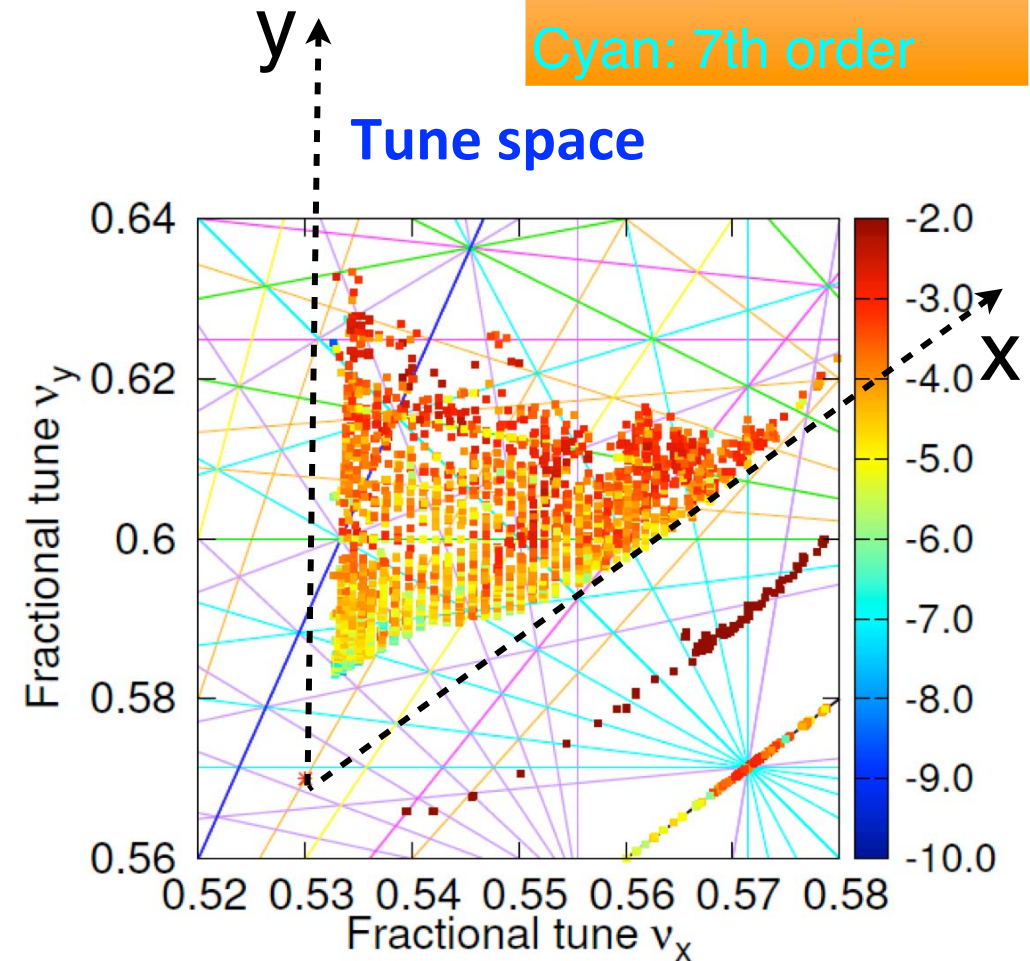
Yellow: 6th order

Cyan: 7th order

Real space



Tune space



2. FMA: LER: δ -x

➤ DA w/o beam-beam

Resonance lines:

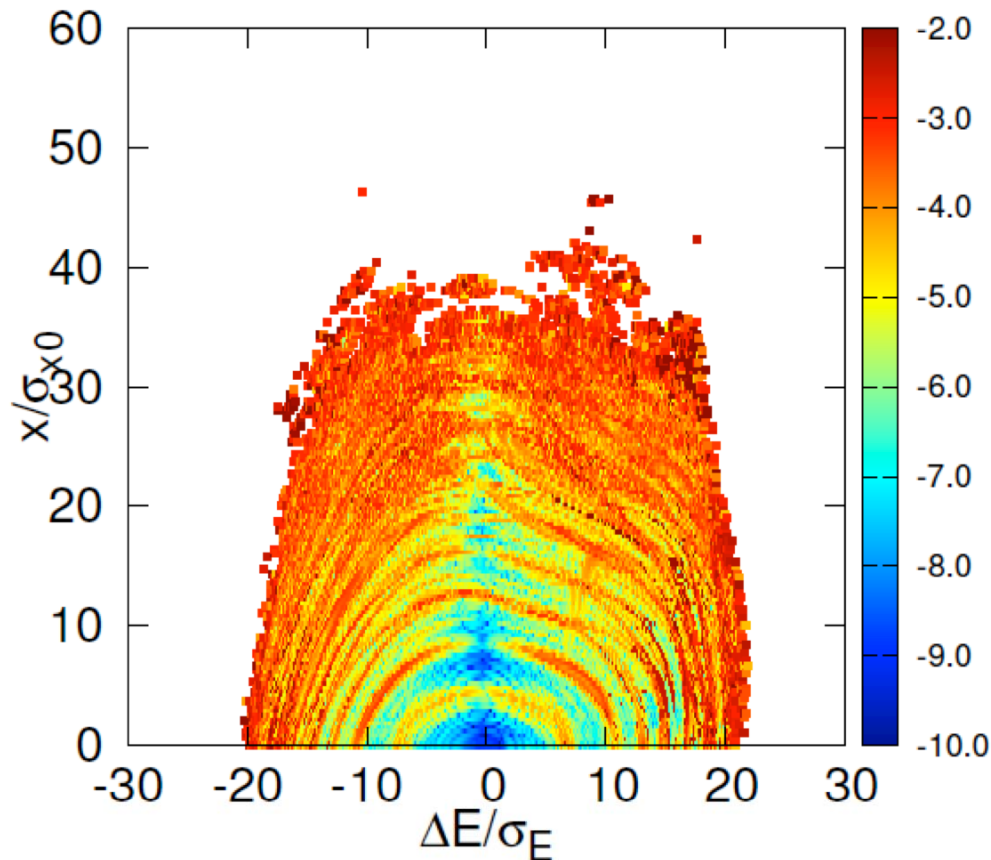
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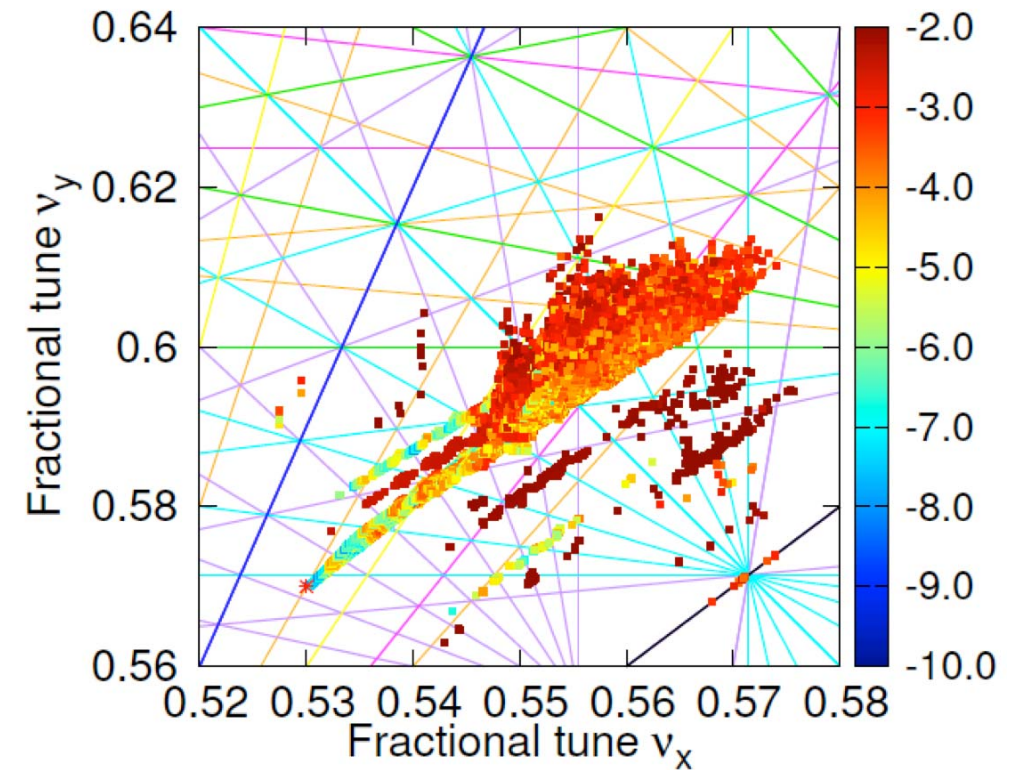
Yellow: 6th order

Cyan: 7th order

δ -x space



Tune space



2. FMA: LER: δ -x

► DA w/ beam-beam

Resonance lines:

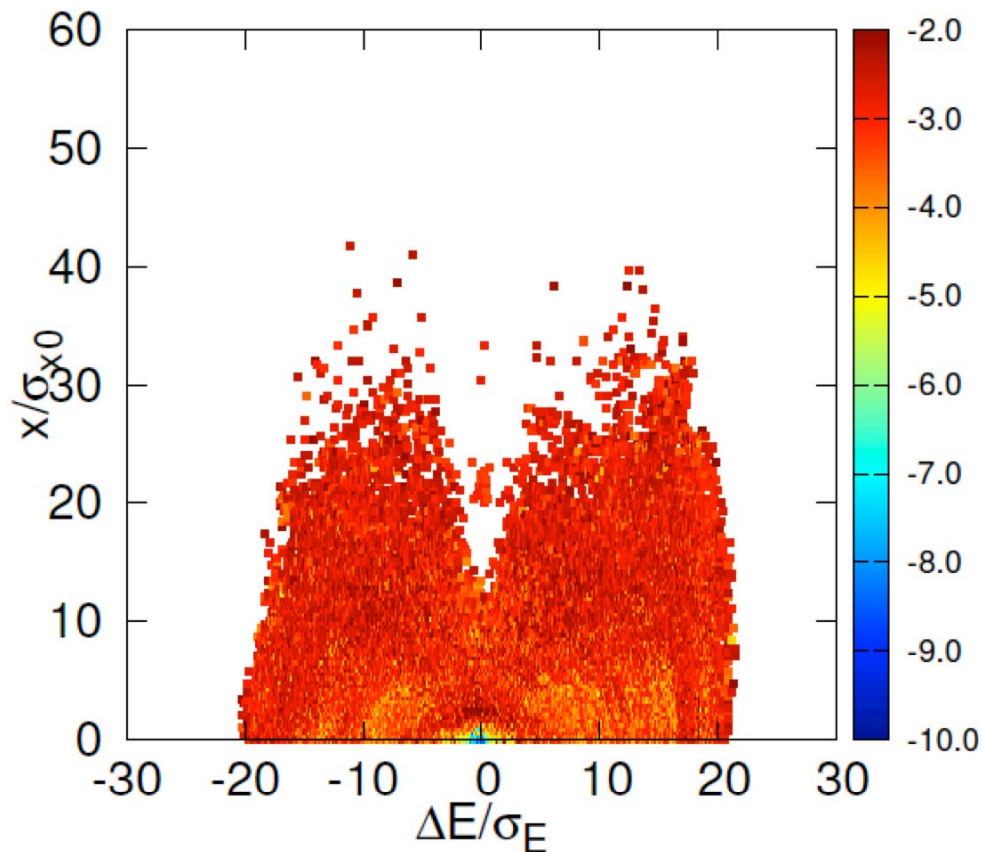
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Green: 5th order

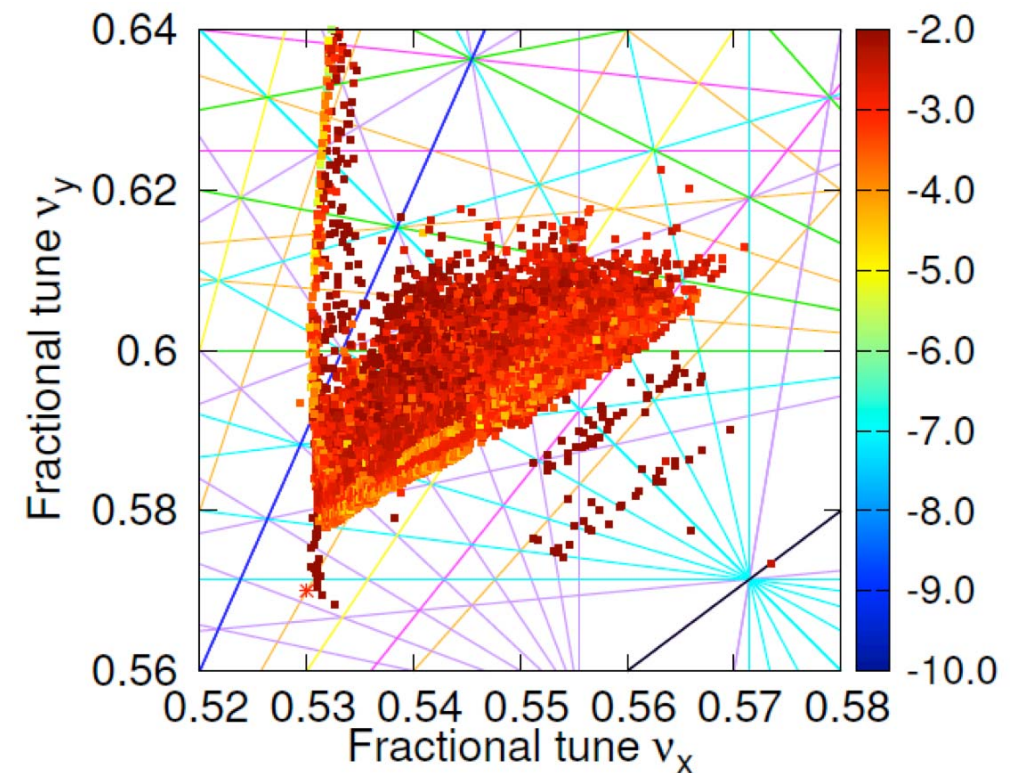
Yellow: 6th order

Cyan: 7th order

δ -x space



Tune space



2. FMA: LER: δ -x

► DA w/ beam-beam and crab waist

Resonance lines:

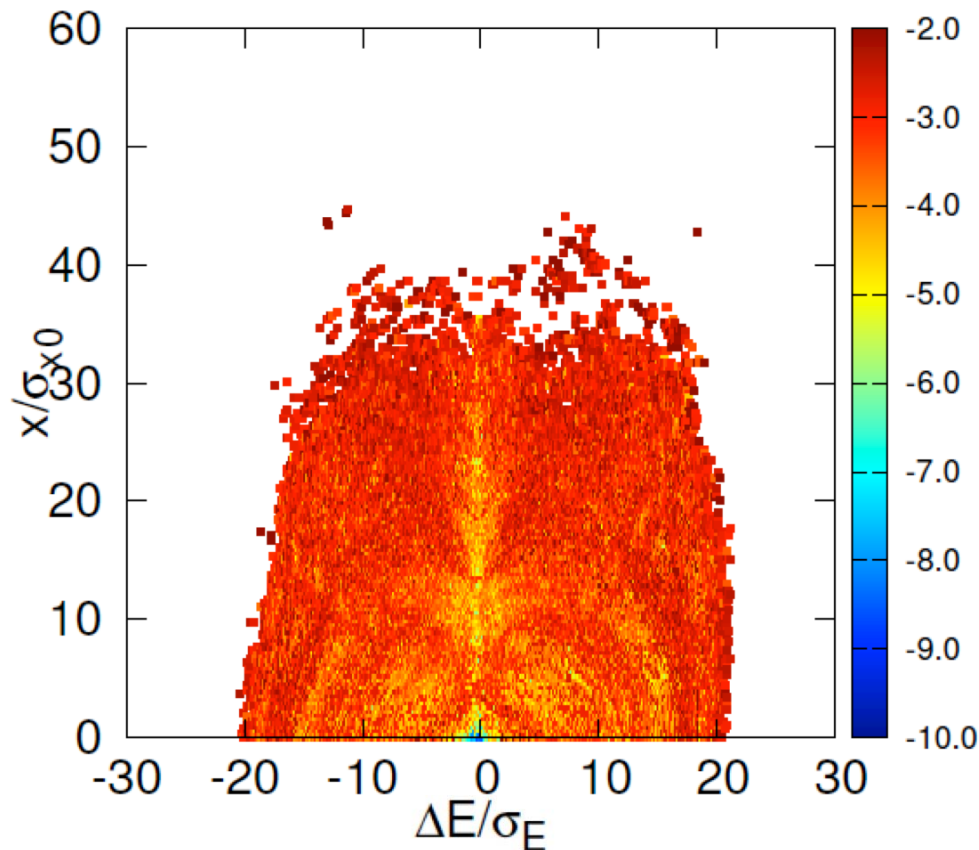
Blue: 4th order

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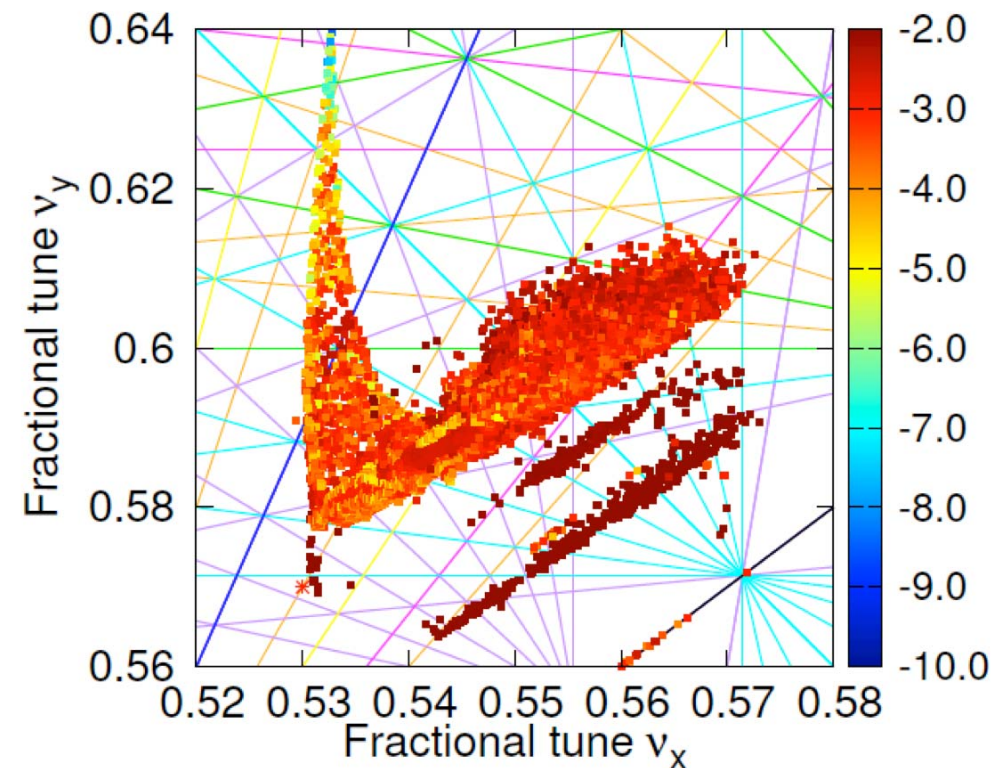
Yellow: 6th order

Cyan: 7th order

δ -x space



Tune space



2. FMA: HER: x-y

➤ DA w/o beam-beam

• On-momentum

Resonance lines:

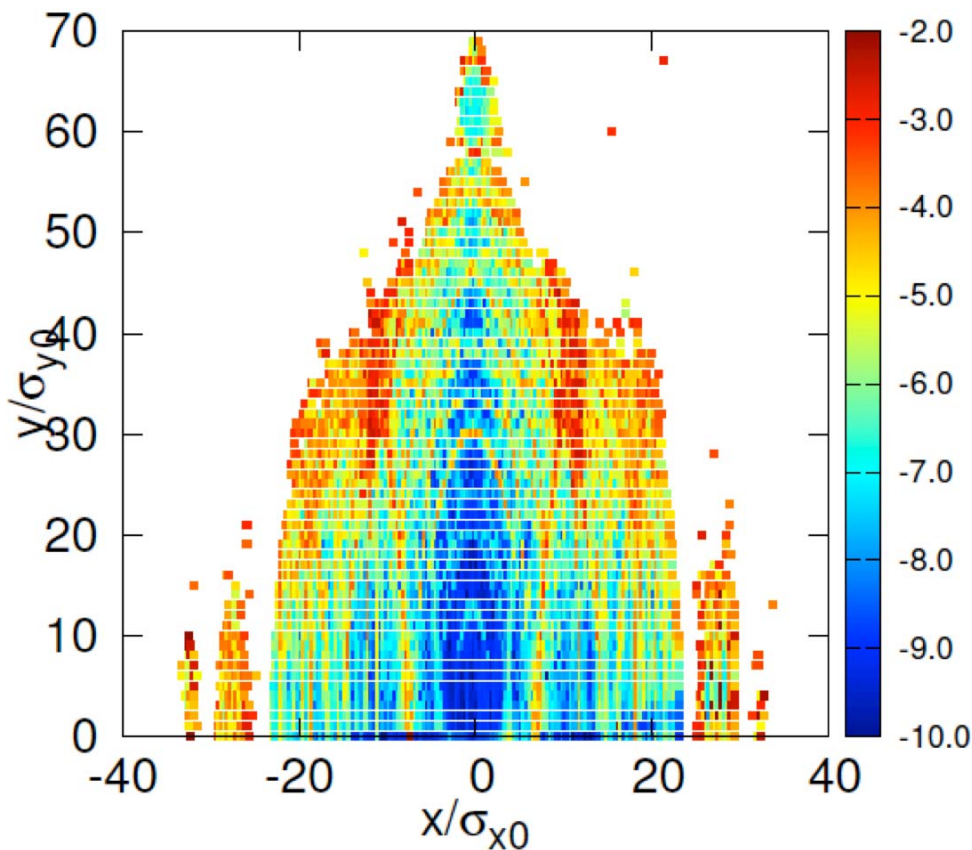
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Green: 5th order

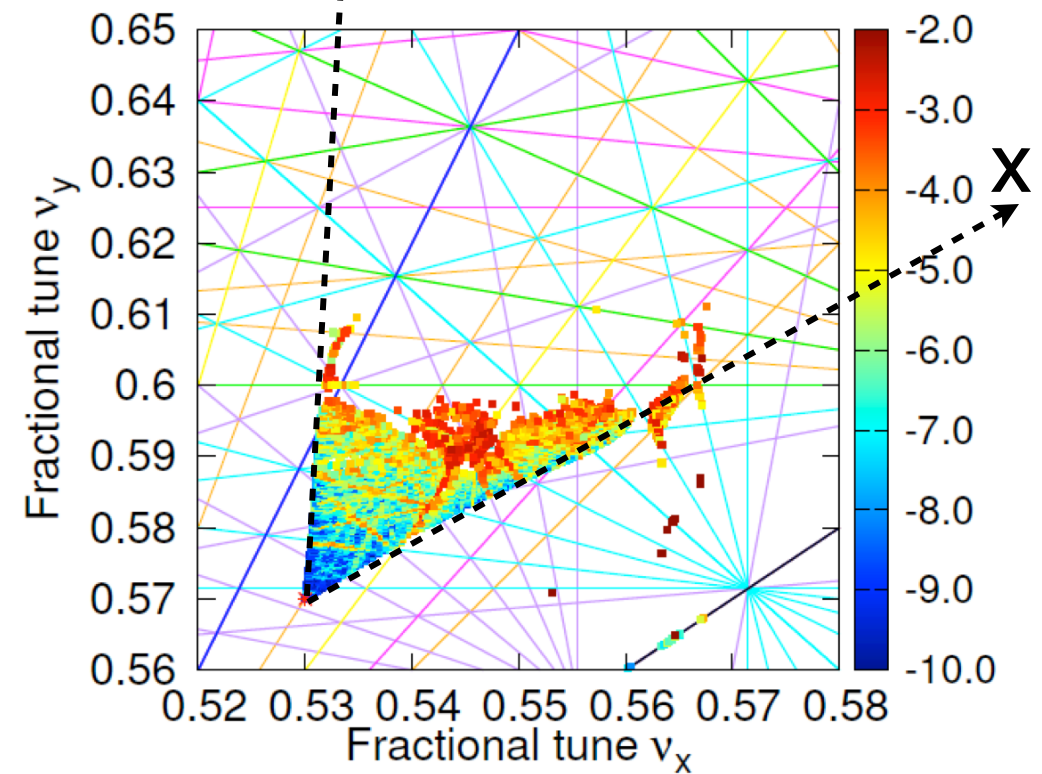
Yellow: 6th order

Cyan: 7th order

Real space



Tune space



2. FMA: HER: x-y

➤ DA w/ beam-beam

• On-momentum

Resonance lines:

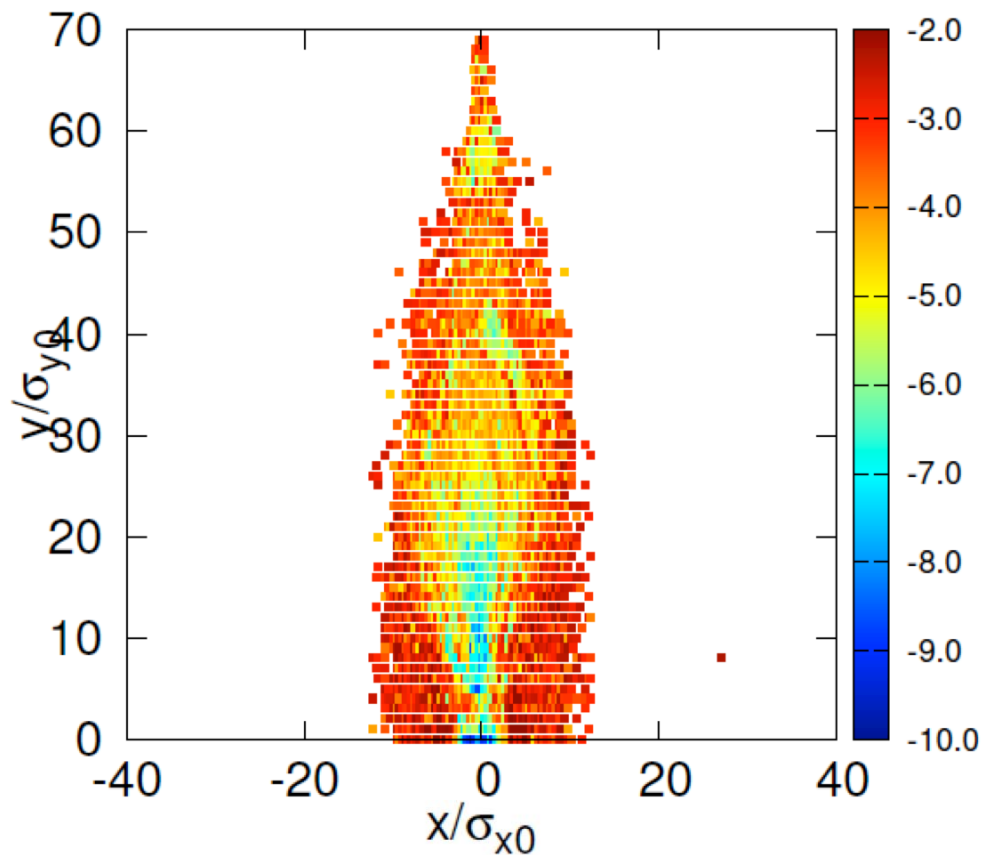
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Green: 5th order

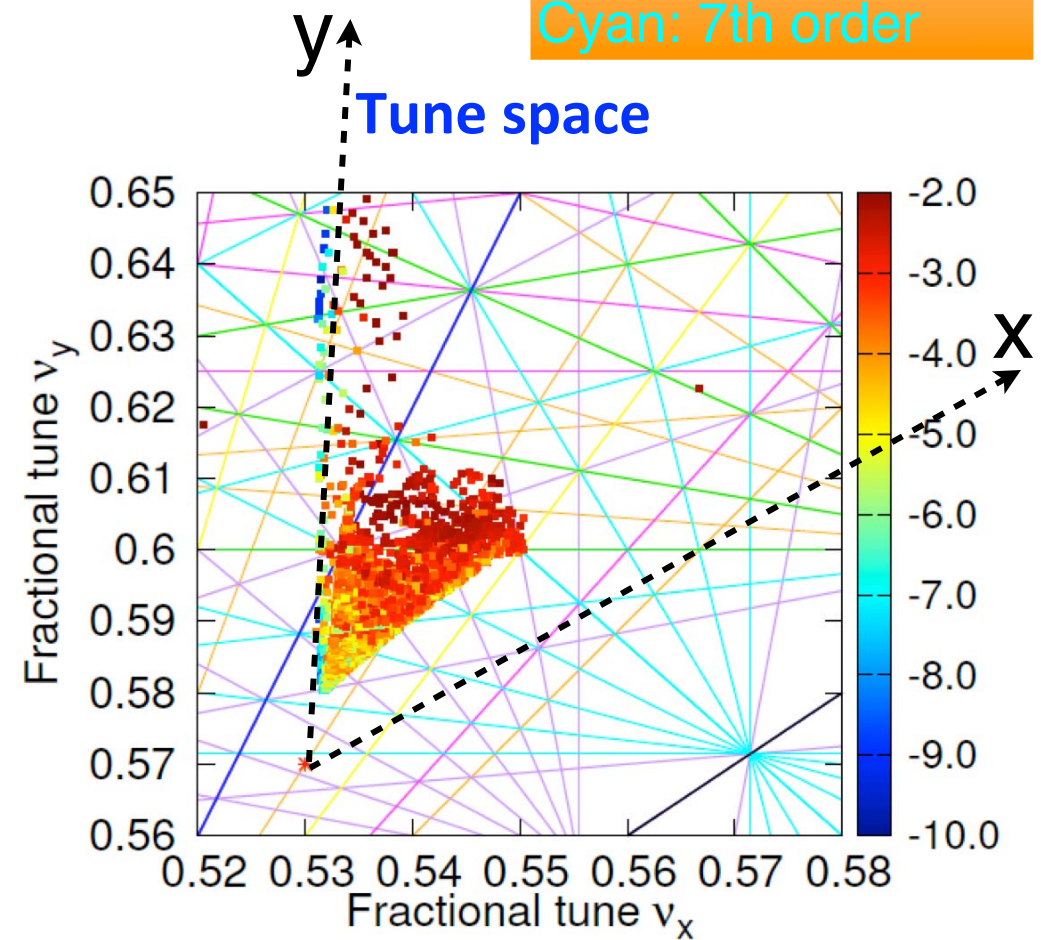
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Cyan: 7th order

Real space



Tune space



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► Beam core: $10\sigma_x \times 10\sigma_y$

• On-momentum

Resonance lines:

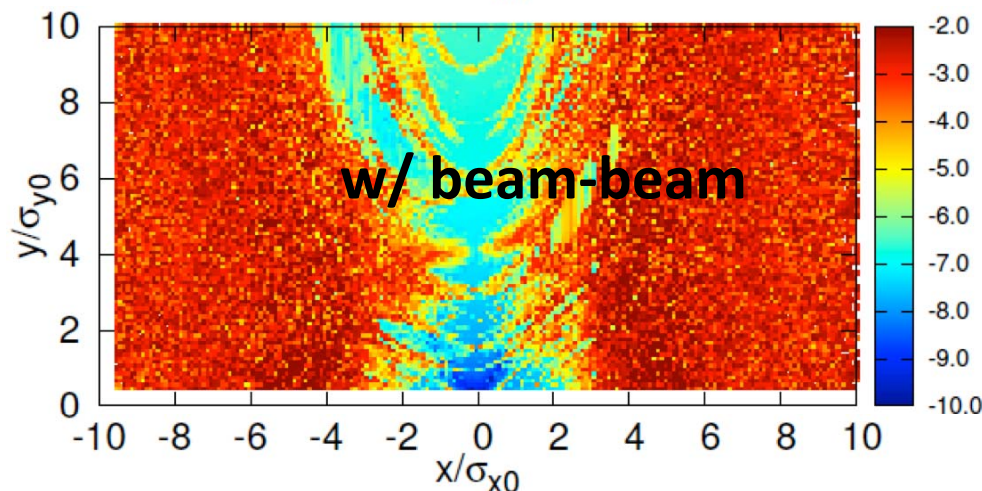
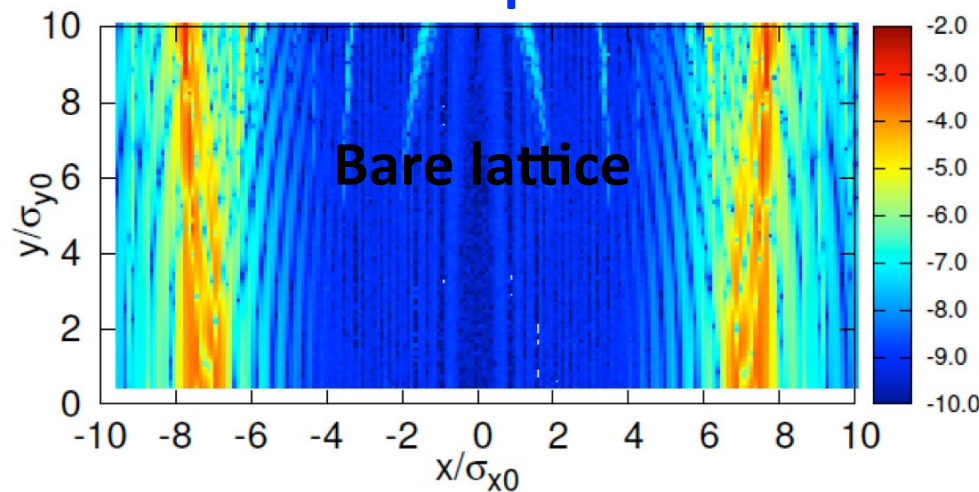
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Green: 5th order

Yellow: 6th order

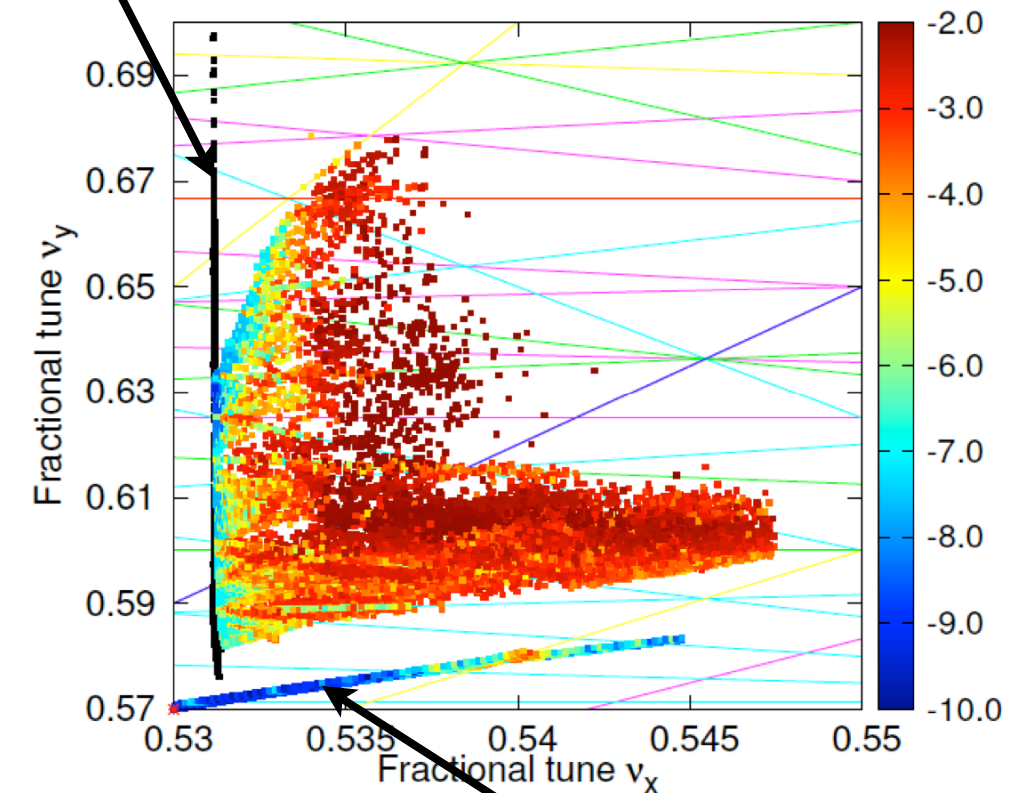
Cyan: 7th order

Real space



BBWS

Tune space



2. FMA: HER: x-y

➤ DA w/ beam-beam and Crab waist

- On-momentum

Resonance lines:

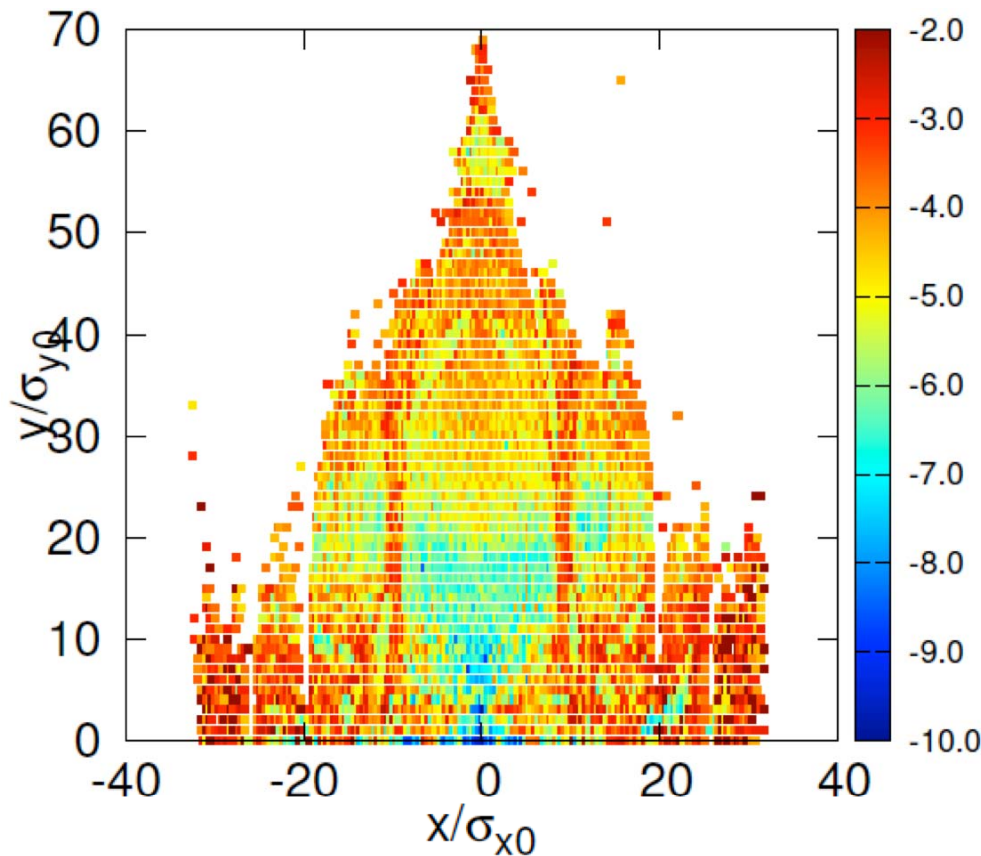
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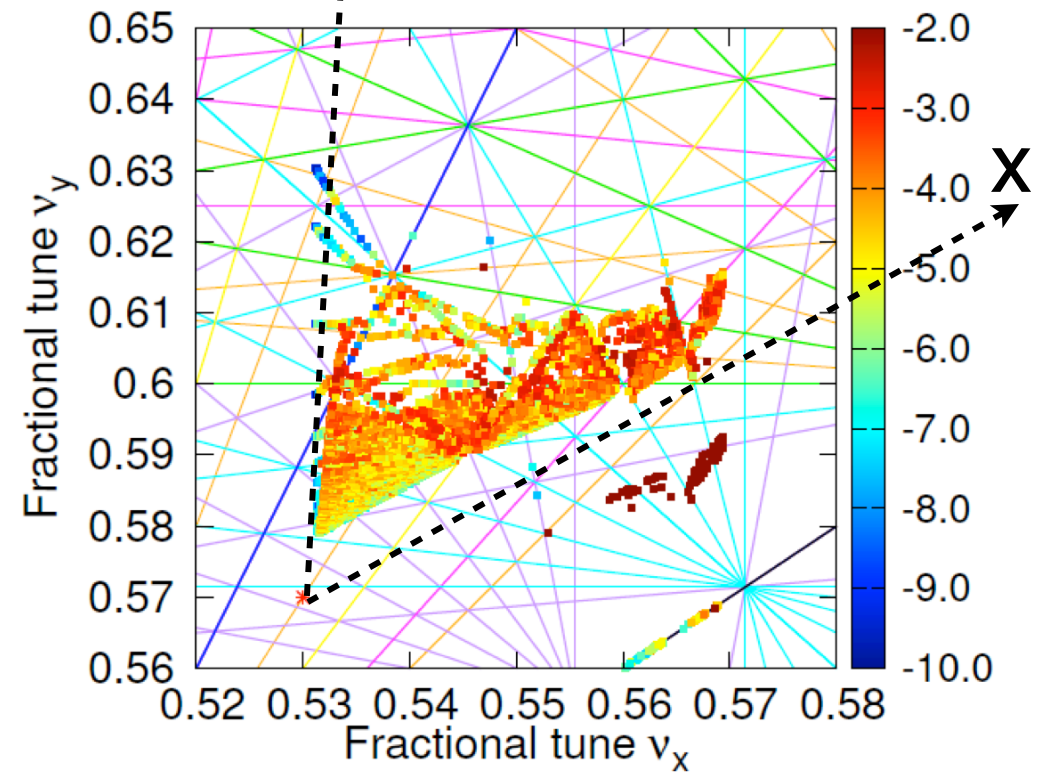
Yellow: 6th order

Cyan: 7th order

Real space



Tune space



2. FMA: HER: δ -x

► DA w/o beam-beam

Resonance lines:

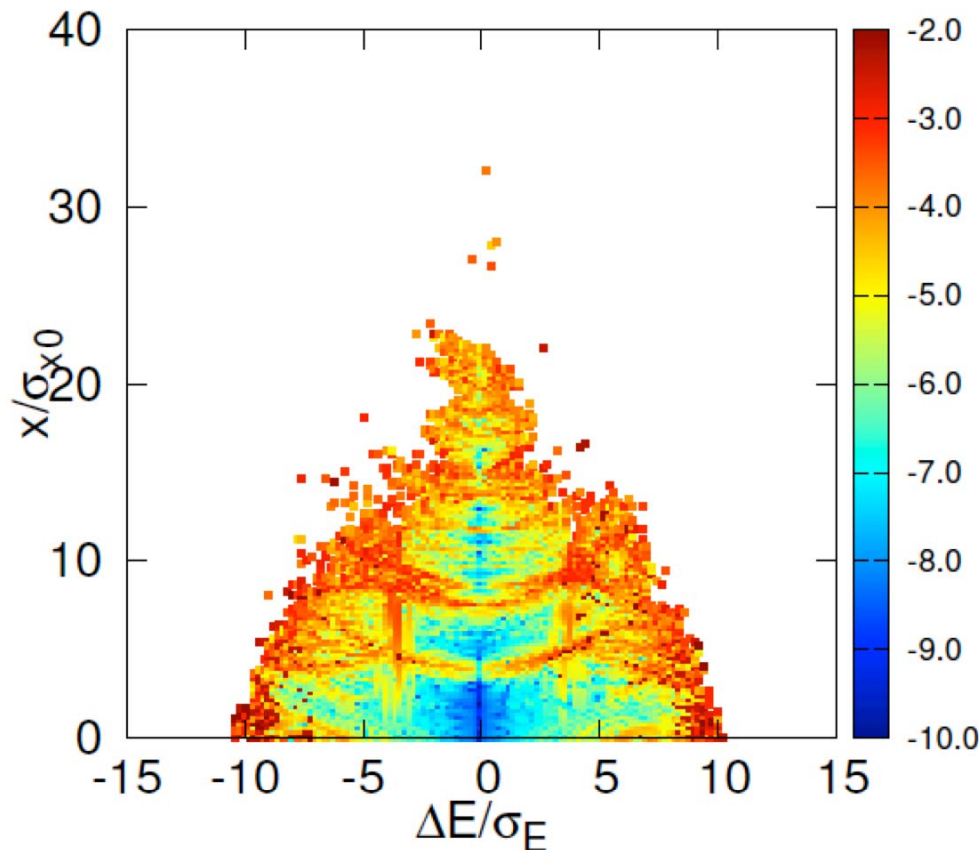
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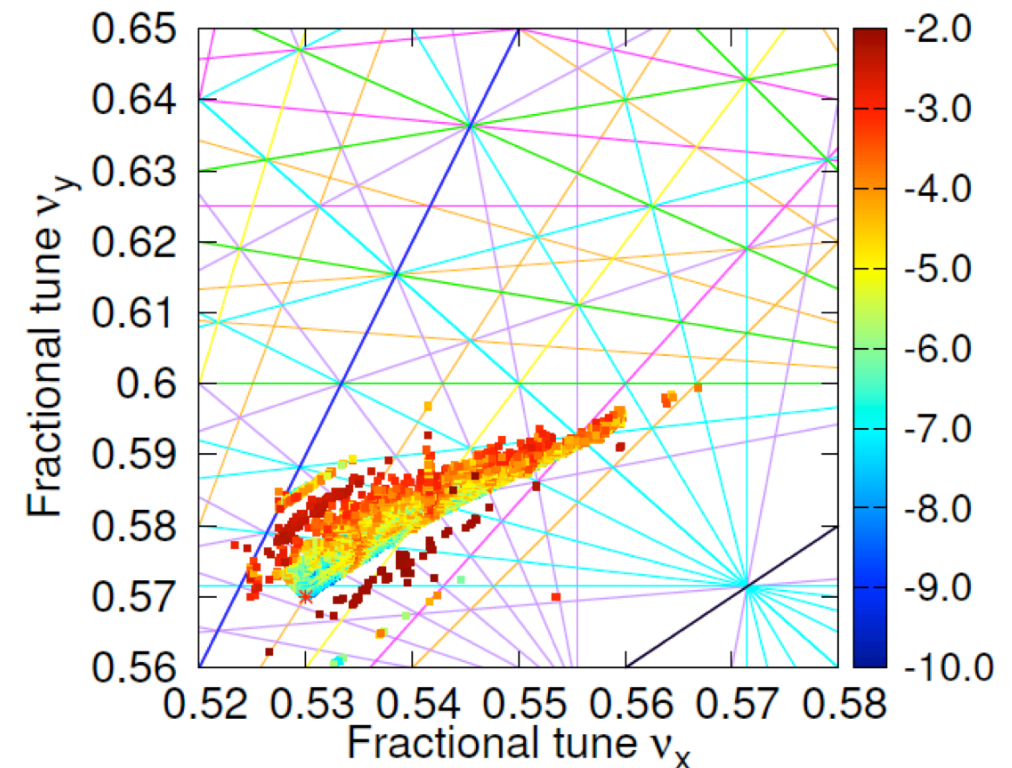
Yellow: 6th order

Cyan: 7th order

δ -x space



Tune space



2. FMA: HER: δ -x

► DA w/ beam-beam

Resonance lines:

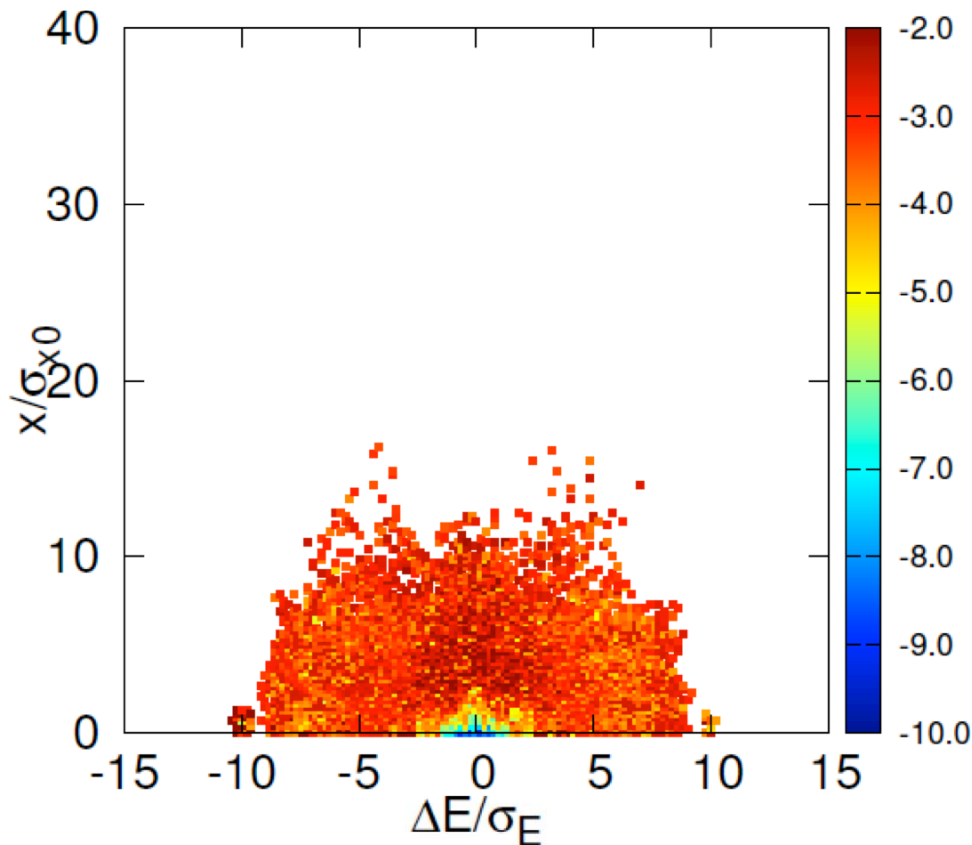
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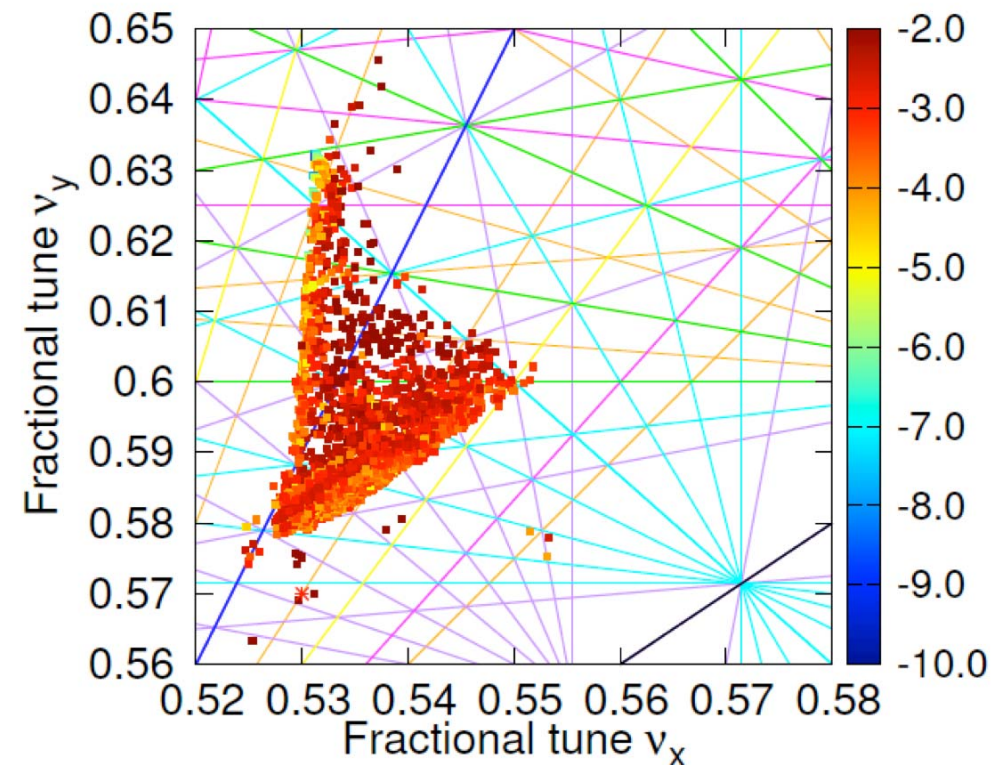
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δ -x space



Tune space



2. FMA: HER: δ -x

► DA w/ beam-beam and Crab waist

Resonance lines:

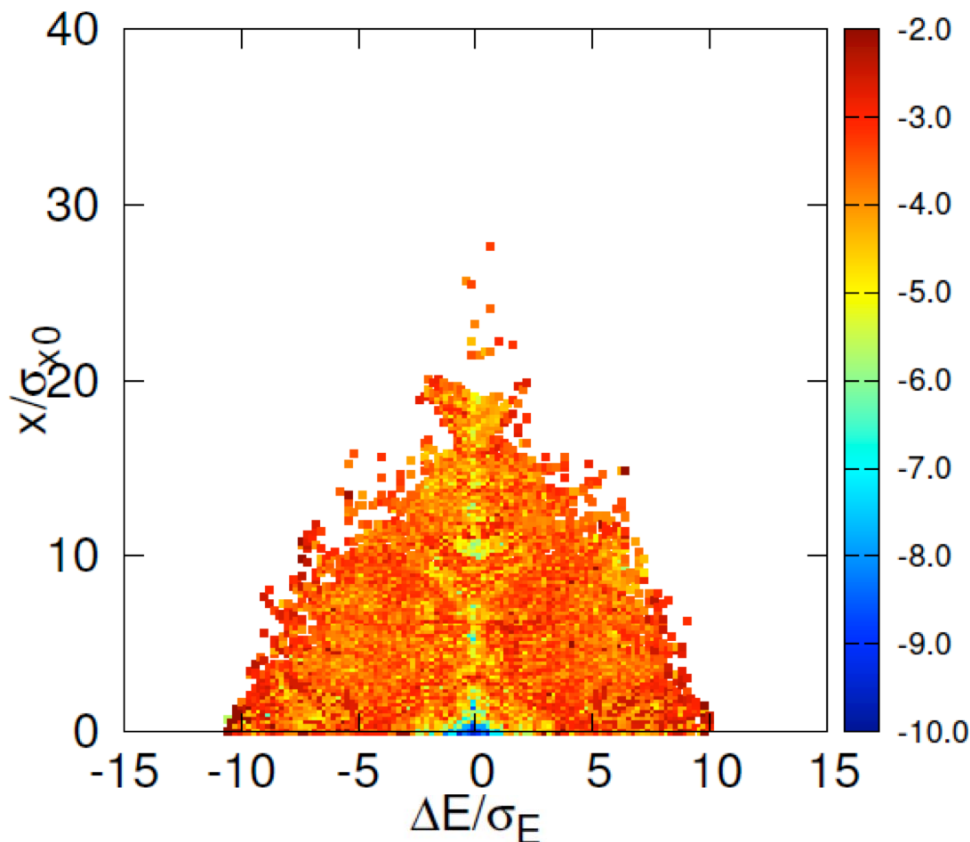
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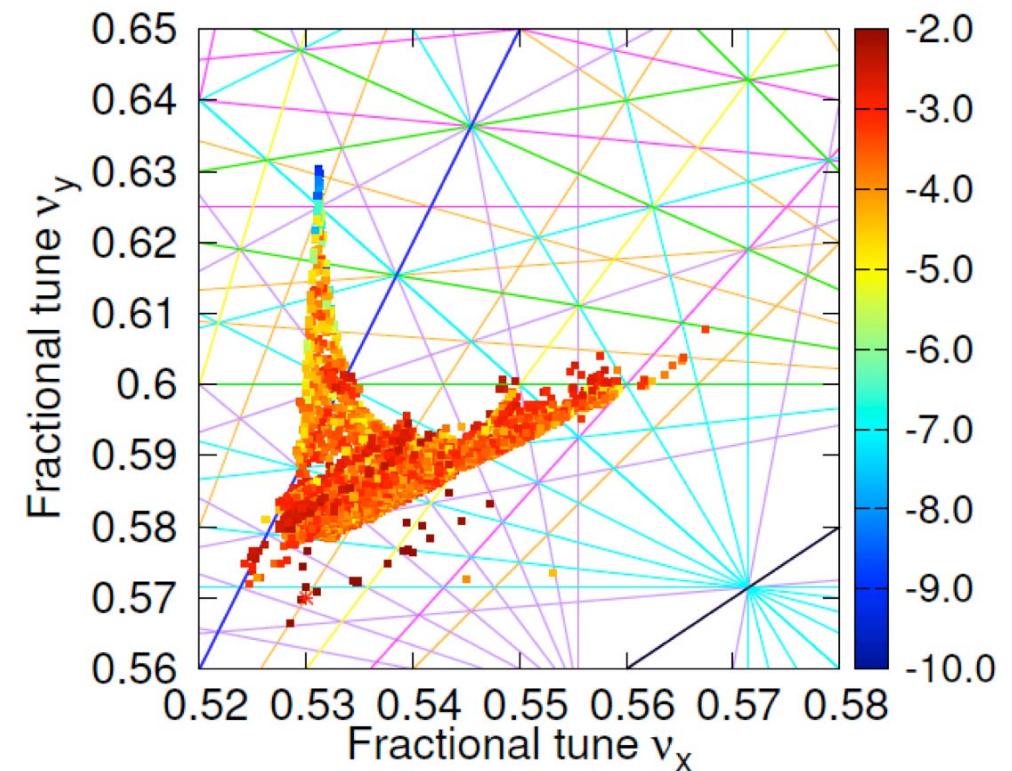
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δ -x space

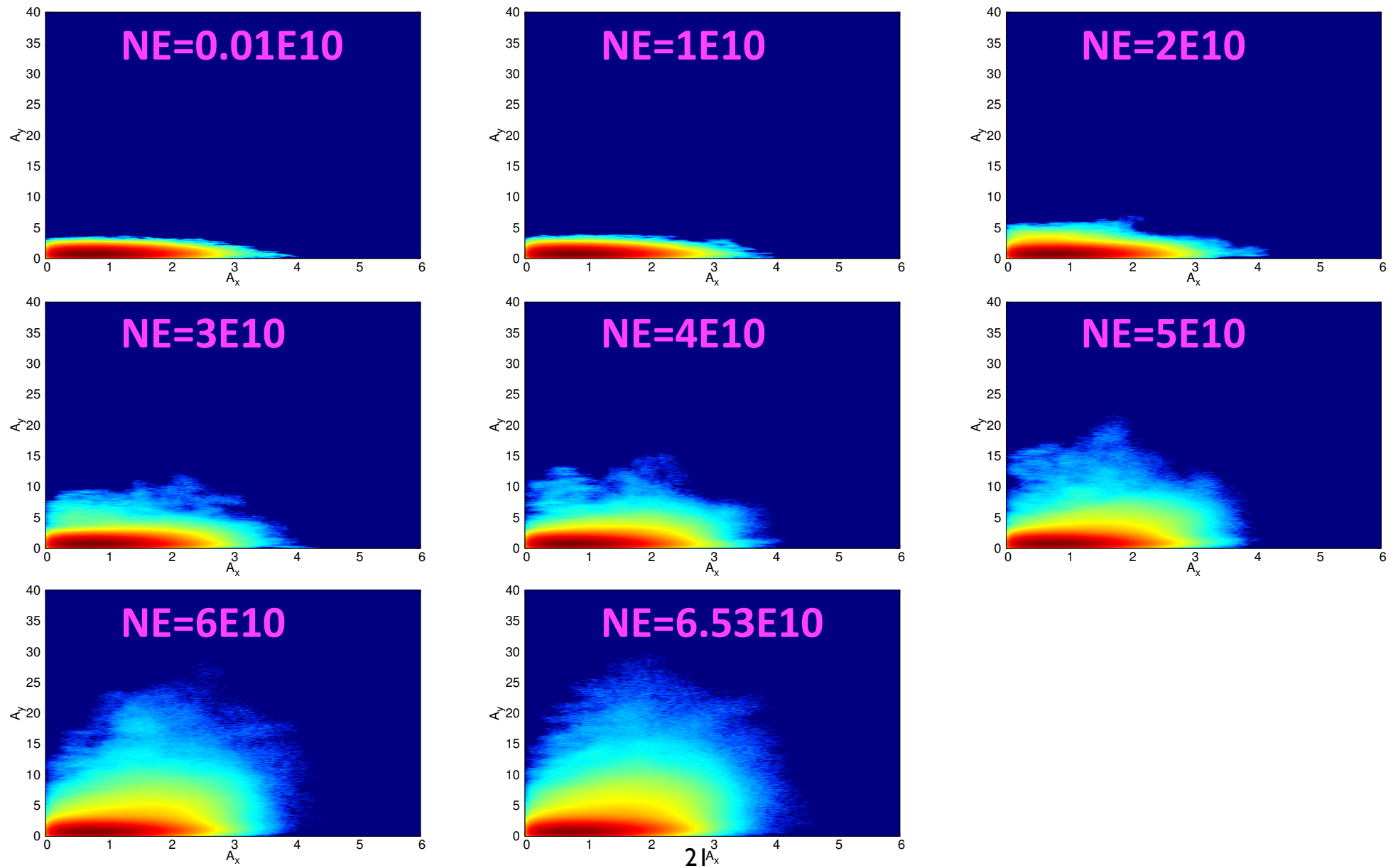


Tune space



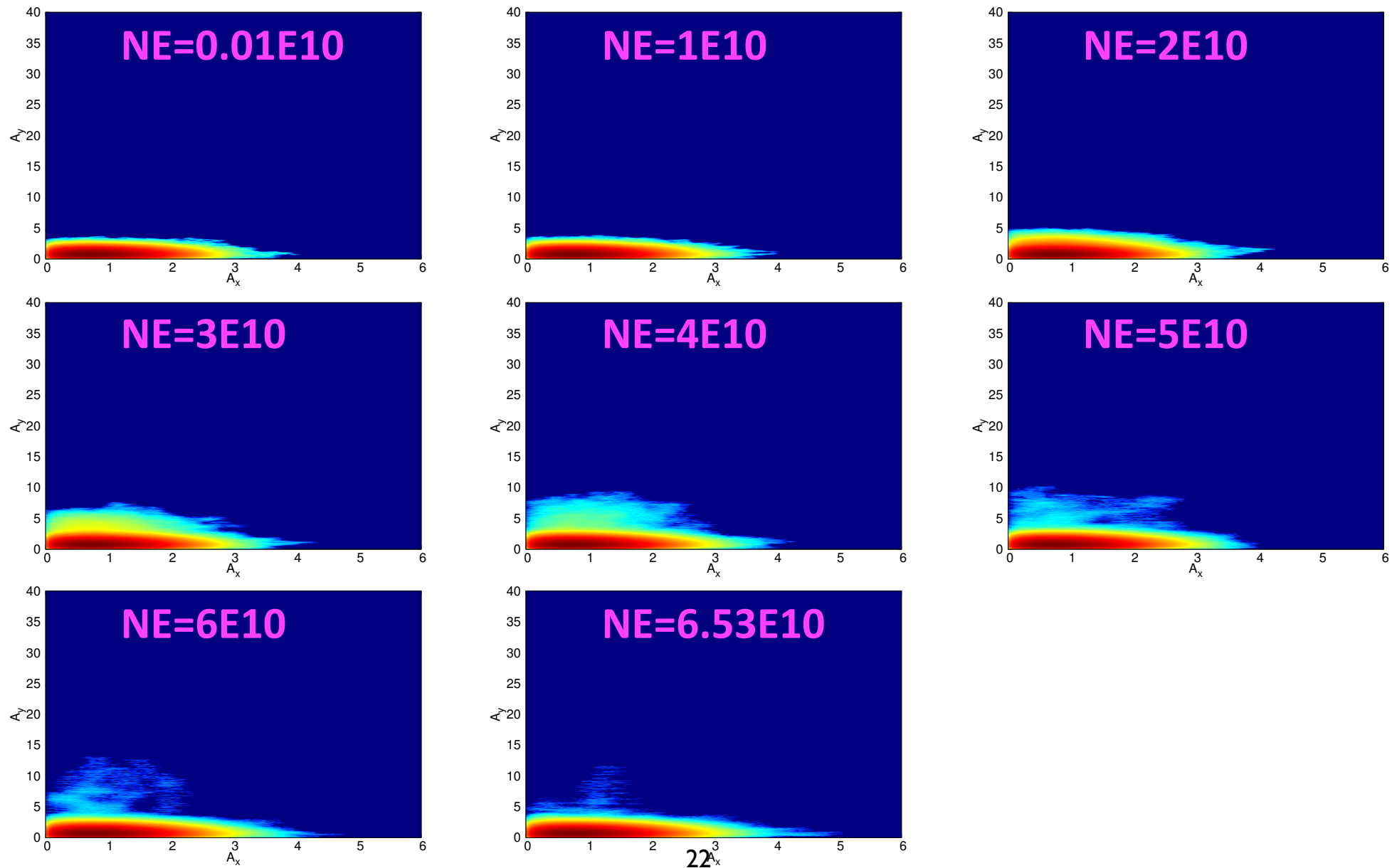
3. Beam tail: **LER**: BBWS: w/ BB

► Tracking: 40000 turns; Statistics: 10000 - 40000 turns



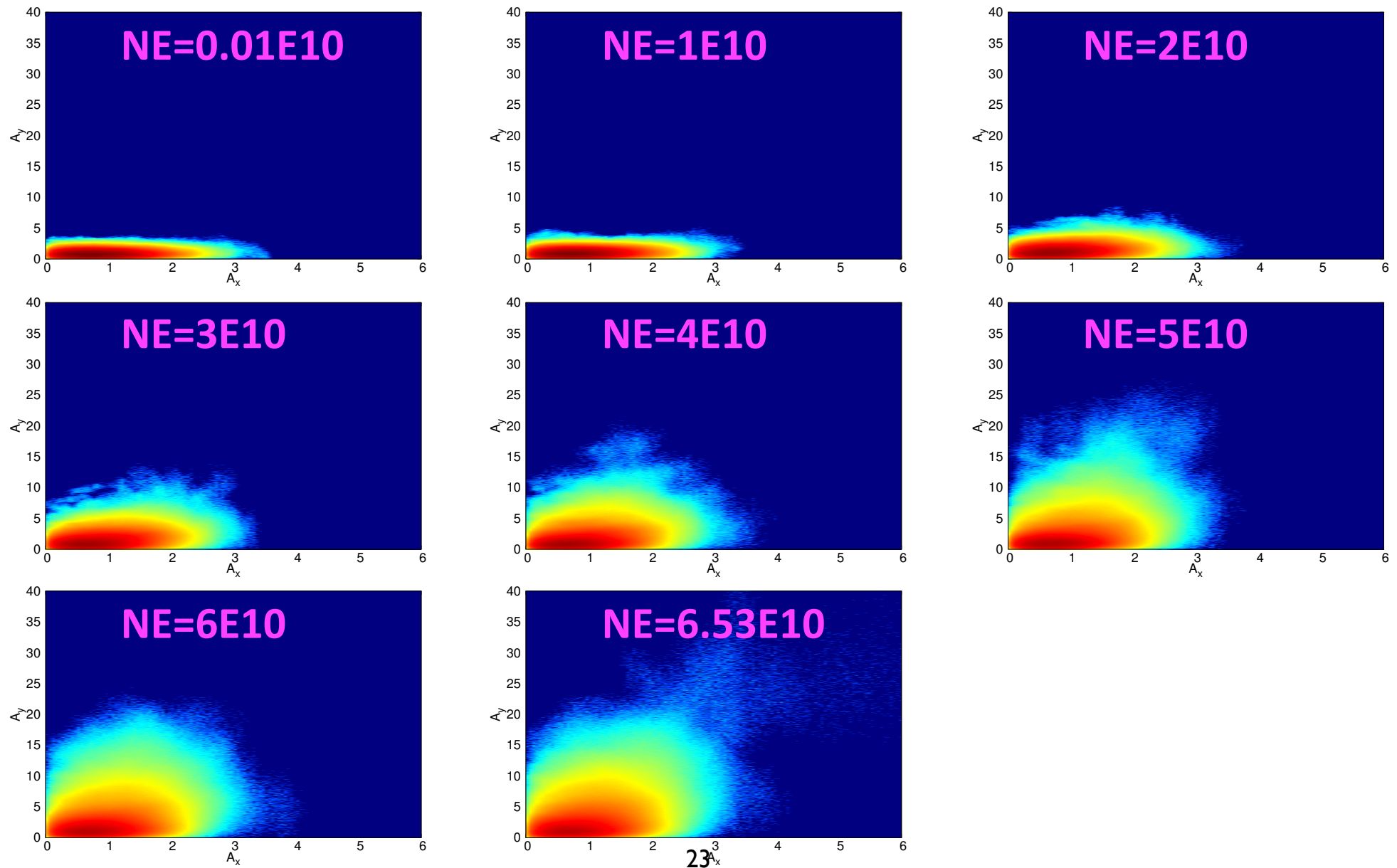
3. Beam tail: **LER**: BBWS: w/ BB & CW

➤ CW works well at high currents



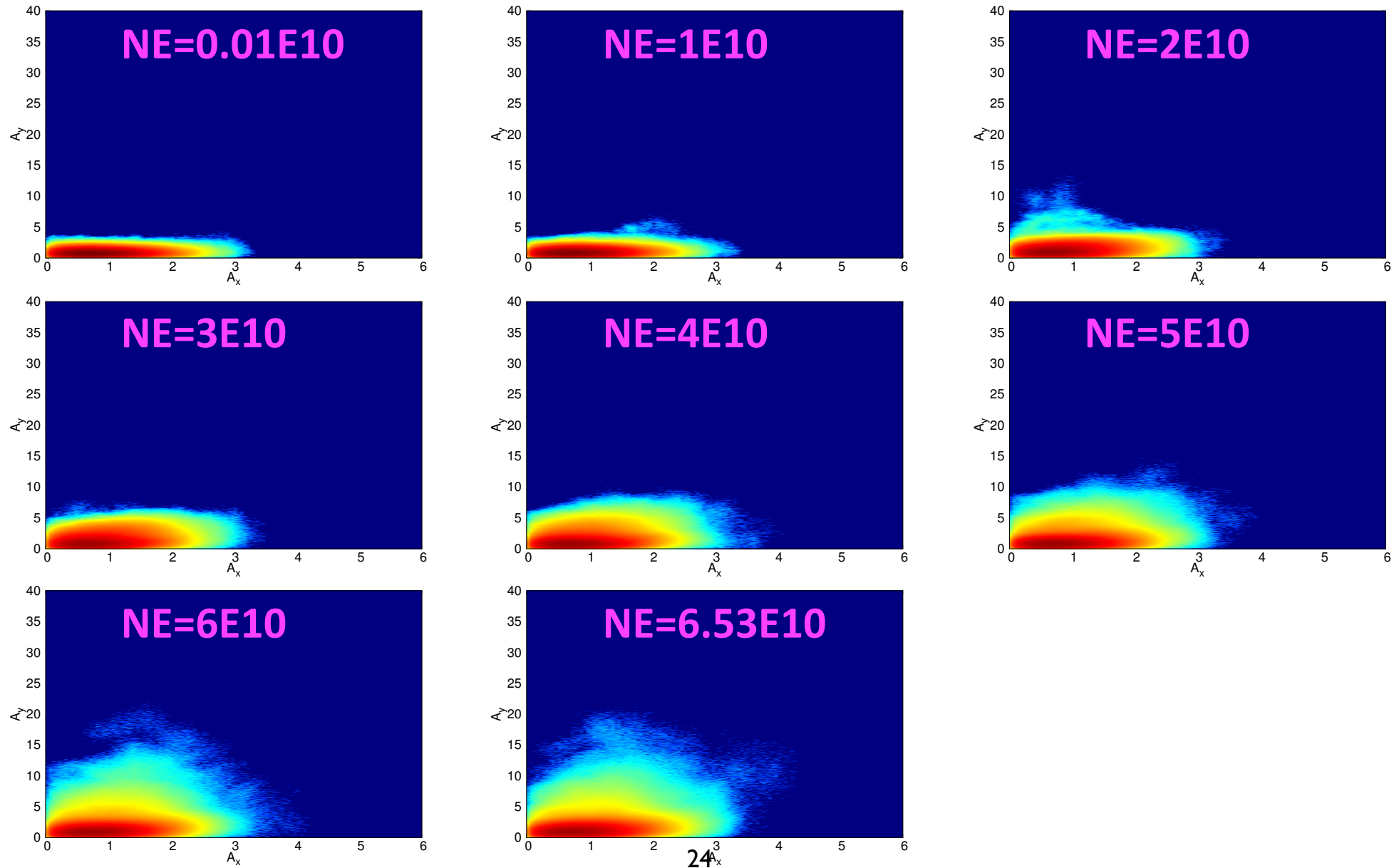
3. Beam tail: LER: SAD: w/ BB

➤ BB enhances X-Y coupling of realistic lattice?



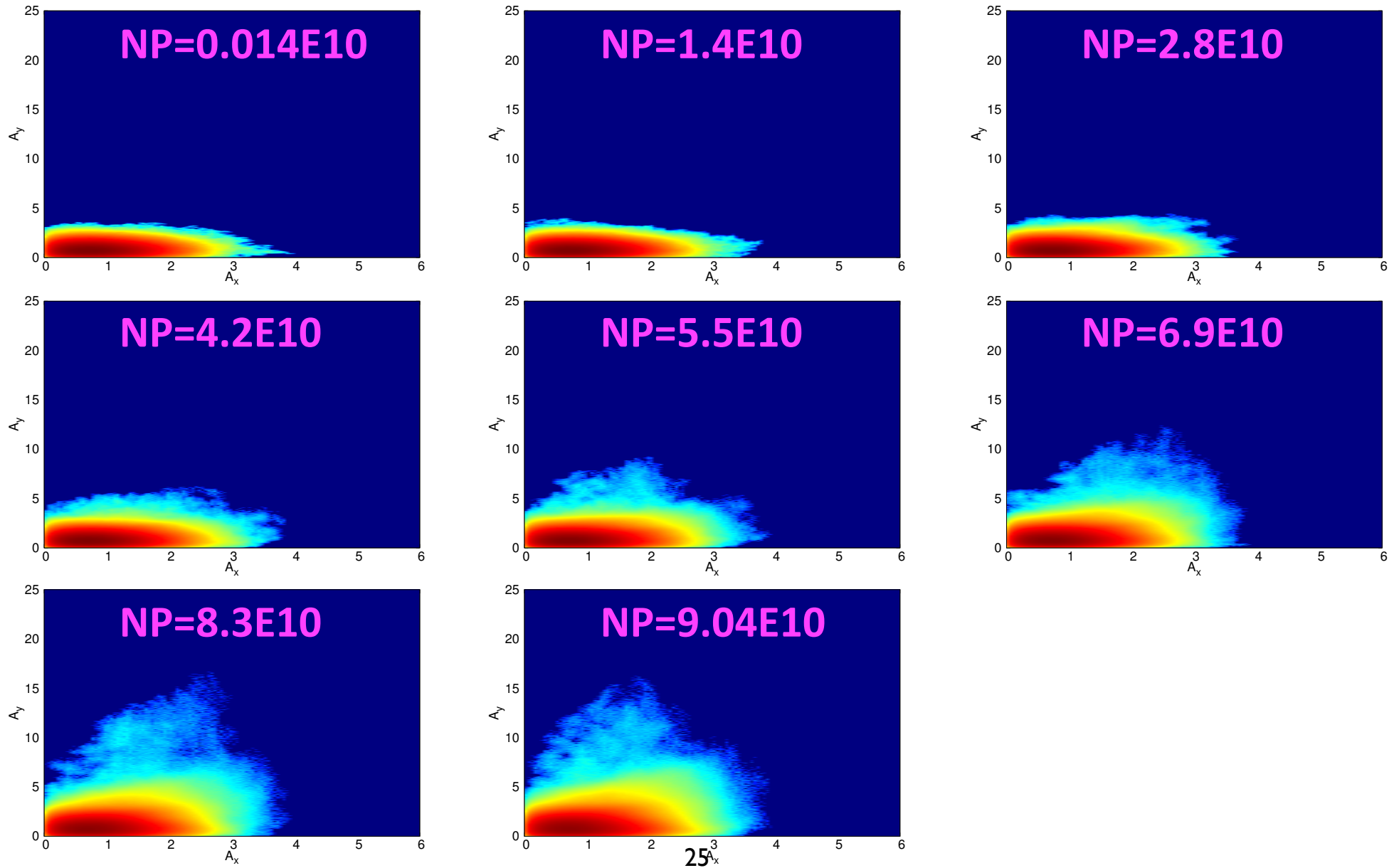
3. Beam tail: LER: SAD: w/ BB & CW

➤ LN degrade CW performance?



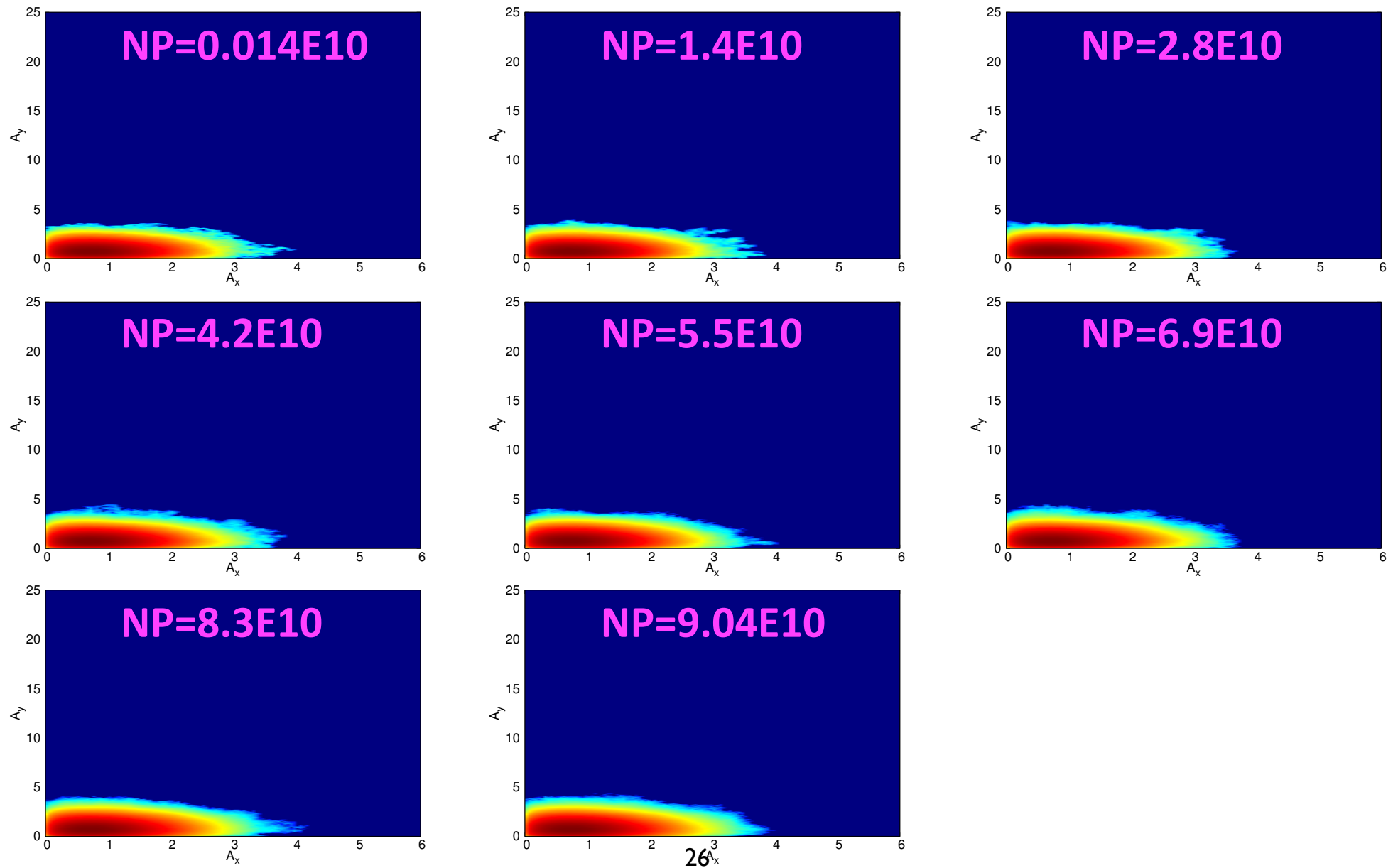
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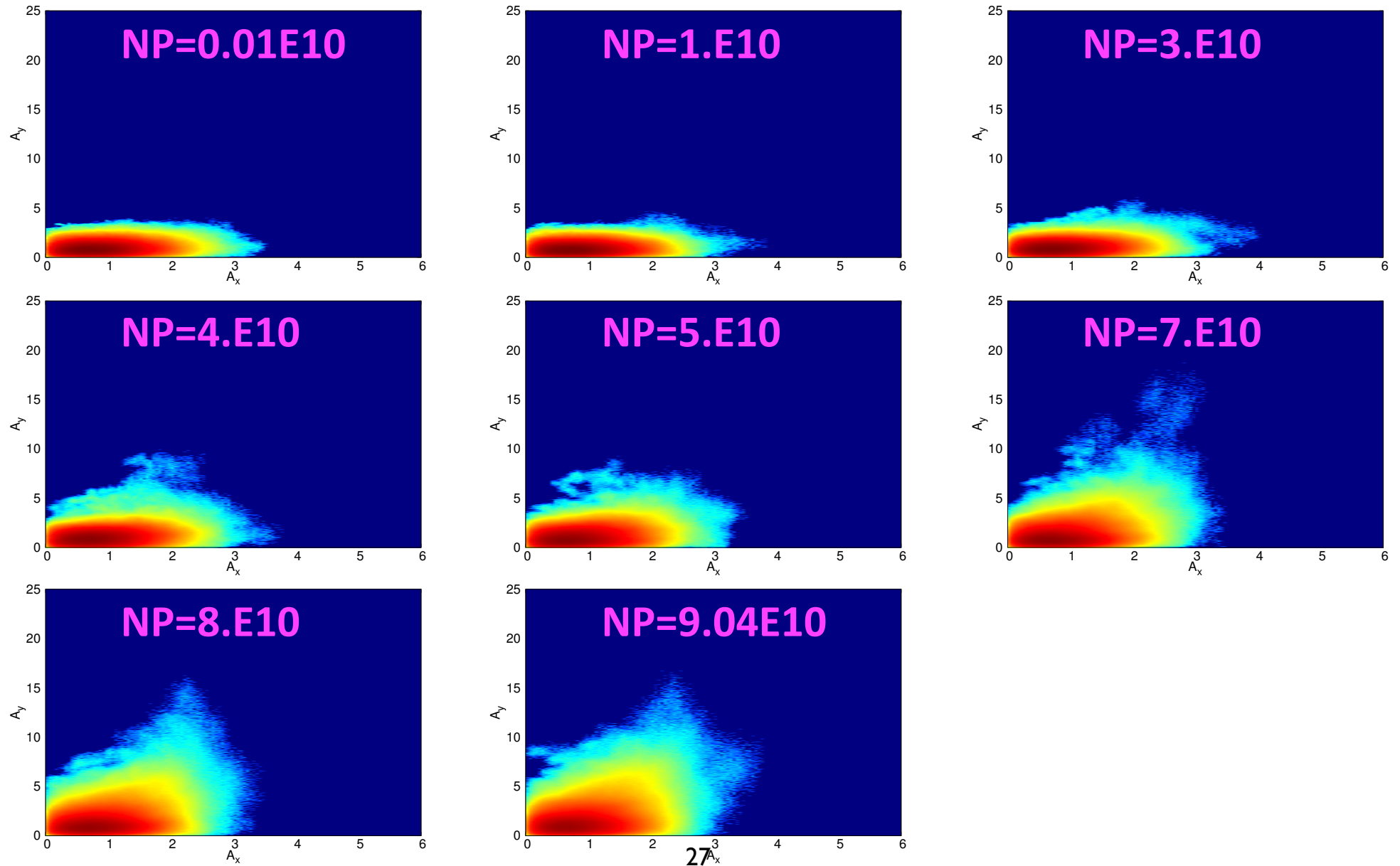
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➤ CW works well at high currents



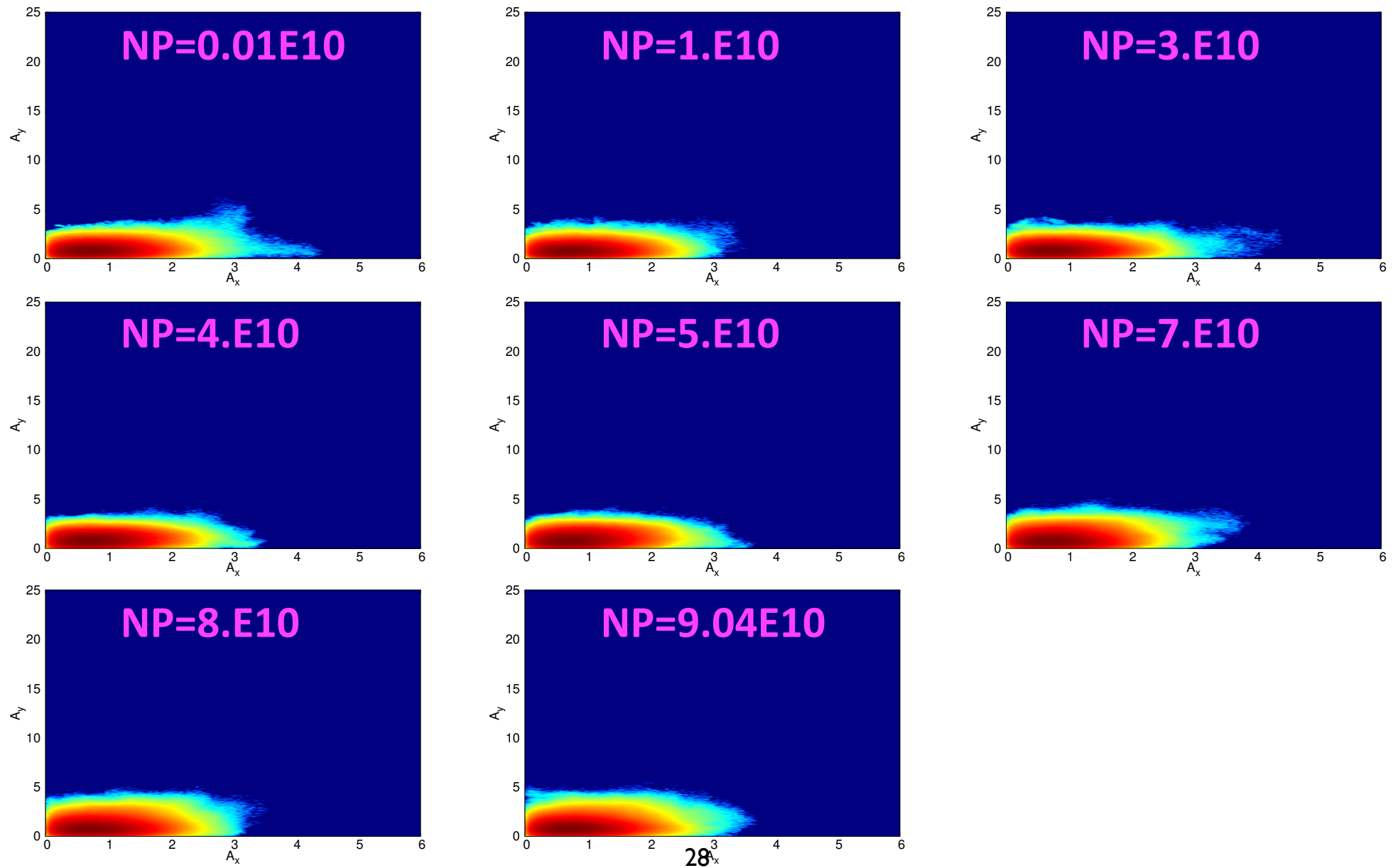
3. Beam tail: HER: SAD: w/ BB

➤ BB enhances X-Y coupling of realistic lattice?



3. Beam tail: HER: SAD: w/ BB & CW

➤ LN degrade CW performance?



4. Summary

➤ Luminosity

- CW recovers lum. significantly
- CW works not perfectly at LER as LN play an role

➤ Dynamic aperture

- CW recovers DA significantly
- CW reduces beam-beam resonances

➤ Beam tail

- CW suppresses beam tail significantly
- LN degrade the performance of CW